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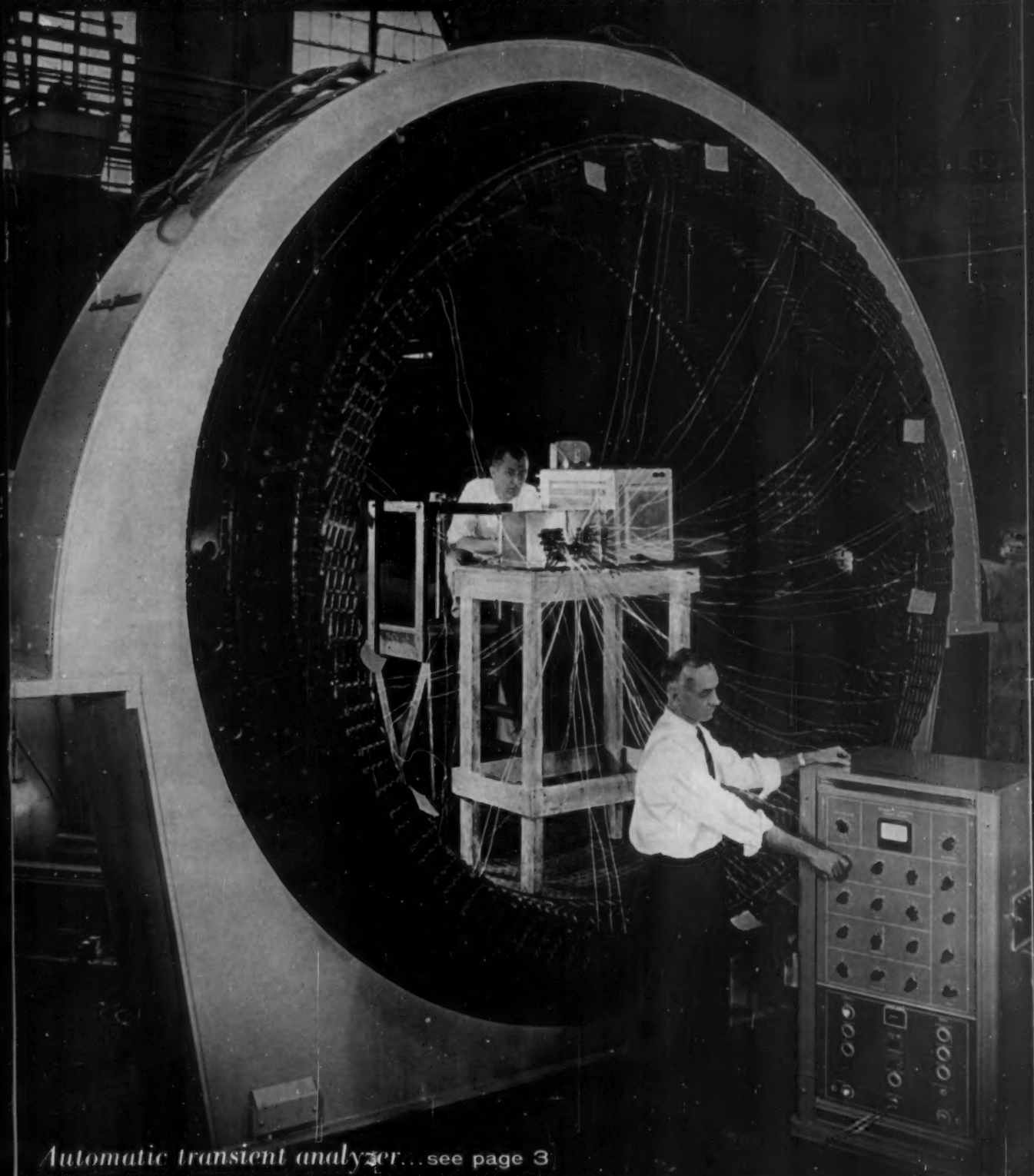
PRODUCT ENGINEERING

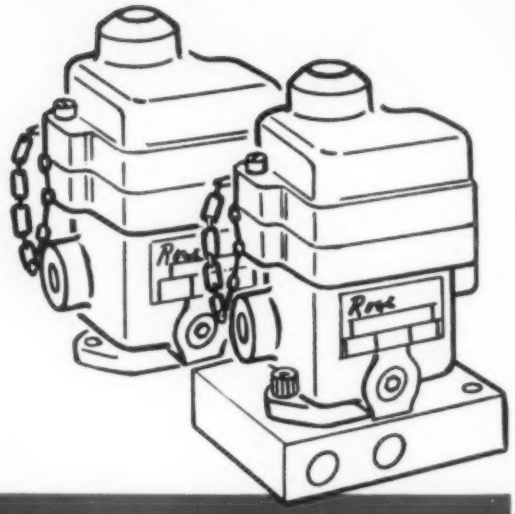
McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · MARCH 7, 1960



Automatic transient analyzer... see page 3

The Ross PACER gives you 56 new solenoid air valves

The Ross PACER is a fine new solenoid valve in the ⅛" and ¼" size range that gives a full ⅜" flow capacity yet uses only 7 watts of holding power. The PACER is built for especially long life yet is priced surprisingly low. Capable of 1000 cycles per minute and more, is JIC, and very light and compact. And if you're interested in large valves the PACER has a second identity, that of a pilot section to actuate *any* valve of the Ross Skyline series. It will operate any of these valves at top speed and with low power consumption.

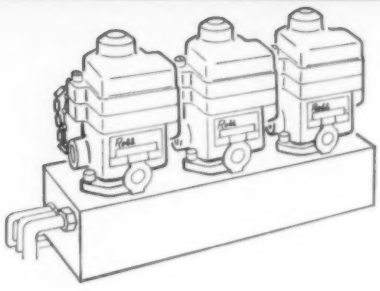


As well as being a complete new valve

...PACER is also a new pilot section in the Ross Skyline valve series...

	PIPE SIZES						
COMPLETE PACER VALVES	⅛"	¼"	⅜"	½"	¾"	1"	1¼"
STRAIGHTWAY, N/C	√	√					
3-WAY, N/C	√	√					
4-WAY	√	√					
SKYLINE VALVES USING PACER AS ACTUATOR (HEAD)							
STRAIGHTWAY, N/C		√	√	√	√	√	√
STRAIGHTWAY, N/O		√	√	√	√	√	√
3-WAY, N/C INLINE MT.		√	√	√	√	√	√
3-WAY N/O, INLINE MT.		√	√	√	√	√	√
3-WAY, N/C, BASE MT.		√	√	√	√	√	√
3-WAY, N/O, BASE MT.		√	√	√	√	√	√
4-WAY, INLINE MT.		√	√	√	√		
4-WAY, BASE MT.		√	√	√	√	√	√
4-WAY, 5-PORT		√	√	√	√		

New PACER manifolds to save piping and wiring



Ross manifolds provide a compact and economical method of multiple mounting PACER valves. One air supply line and one electrical conduit can serve all PACER valves. Manifolds are available in two and three stations.

STAY AHEAD

MODERNIZE

ROSS OPERATING VALVE COMPANY

114 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

March 7, 1960 Vol. 31, No. 10

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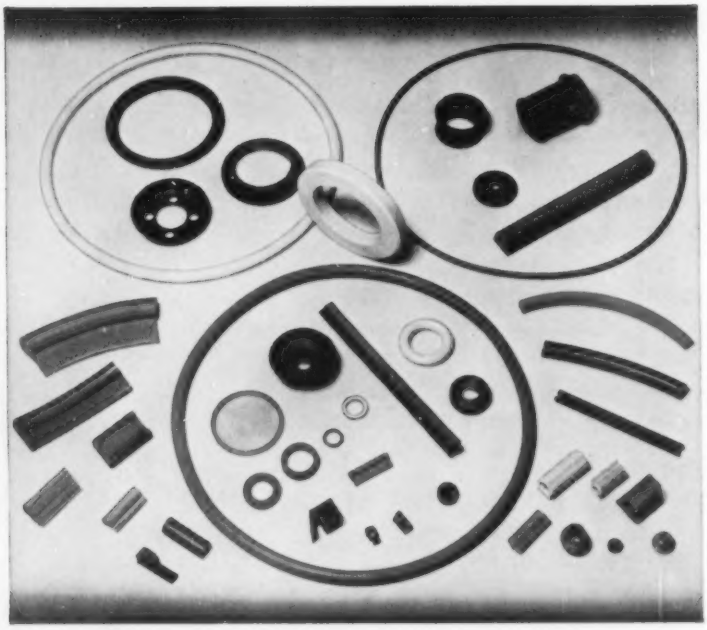
RUBBER
in Design
Engineering



FITTING THE MATERIAL TO THE APPLICATION

No two rubbers are alike. Be sure that, when you design a rubber part, you specify precisely the type of rubber needed for the job involved. Garlock will be glad to offer help, having had years of experience in the engineering and production of molded and extruded, die-cut, and metal bonded parts:

Natural Rubber—used where high tensile strength and resiliency are required. Good air-aging properties. Resists dilute aqueous solutions. Applications include automotive air springs, shock mounts, tubing.

Styrene Butadiene Rubber—used where resistance to aging is important. Good abrasion, water resistance. Readily available, low cost. Applications include weather stripping, pipe joint gaskets, bushings and grommets.

Nitrile Rubber—extremely good oil and gas resistance . . . low solubility, low swelling, good tensile strength, excellent abrasion resistance. Used up to +250° F as oil seals, "O" Ring packing, oil resistant parts.

Neoprene Rubber—relatively unaffected by oxidation, weathering, ozone, sunlight, chemicals. Good resistance to abrasion, cutting, chipping. Applications include bridge pads, flexible couplings, spark plug boots.

Butyl Rubber—outstanding impermeability to gases, excellent dielectric properties, good resistance to tearing after aging. Unaffected by weather, ozone. Used as hydraulic seals, vibration mountings.

Garlock also offers a complete line of specialty rubbers to resist the higher temperatures and more reactive fluids introduced by modern industry and the jet age.

GARLOCK

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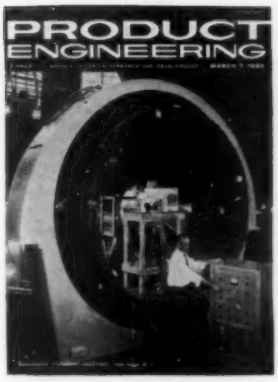
INTERESTING TO NOTE

Research on the Instalment Plan



In 1800, Sir Joseph Banks, president of the Royal Society in London, received word that Alessandro Volta would soon mail the society a letter describing his latest electrical experiments. Volta, in Como, Italy, completed his discourse on March 20, but because of the war between France and England, he cut his document in two, mailing each half separately. This way, Volta hoped, at least part of his report would pass through France to England. Within a few weeks, Sir Joseph received the first half of Volta's work. It wasn't until late June, however, before the second instalment finally arrived. The paper described the voltaic pile, forerunner of the modern battery.

Volta is remembered today not so much for his electric pile or his work with dissimilar metals, but for the unit of electrical measurement named after him. Voltage is still not fully understood, and scientists continue to study its behavior. A new and simplified high-speed way to study short-time over-voltage phenomena in various engineering devices and systems recently was devised by General Electric.

This automatic transient analyzer lets engineers trouble-shoot transient voltage distribution in rotating machines, sometimes in one-fourth the time required by manual methods. The analyzer has a large cabinet containing a surge generator with a maximum output of 1500 volts.

A smaller cabinet, on which a stepping switch is mounted, scans any circuit connected to it. Also built into the package is a high-writing-speed, cathode-ray oscilloscope with an automatic camera. With data derived from the analyzer, engineers can quickly check various motor connections and winding circuitry for their response to known short-time voltages that appear on the machine terminals. Our cover photo shows General Engineering Laboratory's Don Schoenberger (foreground) and Ed Schrom running a test on a stator.

His Bubbles Fight the Sea

Every year millions of dollars are spent repairing the damage caused by nature's action upon our land. Earthquakes, floods and hurricanes make headlines, but nature's more subtle forces are rarely mentioned. Tons of our finest topsoil are stripped from the land and carried to the sea; ice cracks and buckles our highways; waves and tides continuously gnaw at our coastline, destroying our beaches and harbors. But we are learning countermeasures.

In 1900 a young man named Philip Brasher took a summer job with an amusement company at Brighton Beach, NY. He watched with curiosity as a $125,000 jetty was constructed to control wave damage to the beach. Later

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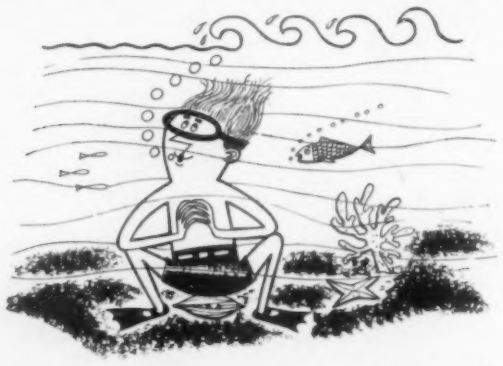
he saw what happened to the jetty when the first of the late summer storms struck—within three hours a quarter of the jetty had been battered to pieces. This experience started young Brasher thinking about a better way to curb action of waves. "I visualized the problem as similar to that of stopping a ball carrier in a football game," Brasher explained later, "You can do it by getting in his way, but a far better and easier method is to grab him by an ankle and upset him."

Brasher studied the problem for many years, developing the theory that a vertical force was needed to lessen a wave's horizontal drive. The vertical force Brasher elected was air. He experimented in laboratory wave tanks, but soon found it necessary to test his ideas at sea rather than the lab. In 1908, Brasher set up an experimental station at Crotch Island, using a compressor from a local



quarry to supply the air needed. This was fed via 100 ft of perforated 3-in. tubing to the area beyond the wave's breaking point. The size of the waves was reduced, but Brasher had too little time to find a way to measure the reduction in shore erosion.

However, while at that Maine island, he received a call from a salvage crew that was trying to refloat the US cruiser Yankee. This ship had come to grief on a reef off Buzzards Bay, Mass. Brasher was put aboard the ship with his equipment and quickly connected the Yankee's three air compressors to pipes beneath the sea.

The flow of bubbles subdued the 20-ft waves, and a salvage crew freed the ship. However, the work was wasted, for as soon as the Yankee cleared the reef, the damage to her hull prevented her from staying afloat. She sank, taking with her all Brasher's data.

During the past 50 years, Brasher has devoted his life trying to prove that air compressors (p 47) can calm rough seas. His system has been successfully applied dozens of times, but never permanently. British engineers at Dover, England have recently been experimenting with compressed air as a breakwater, but engineers in the United States are still waiting for "concrete results." Not too long ago, for example, Brasher offered to put in a $60,000 system to prevent wave erosion to a New Jersey resort. He said he would not accept payment unless his "bubble breakwater" did exactly as it was supposed to do. His proposition was rejected. —Benedict A Leerburger Jr

SIDELIGHTS

We received an urgent call the other day from the sweet-voiced young secretary to an obviously very busy man. Had to have a reprint, or at the least the issue date and page, of an article entitled something like *Integral Speed Reducers*. Well, we'd had a lot on speed reducers, some in the integral-hp range. Who was the author? "His name is Eddie Current," she said. "Sure, sure—never mind the gags. What was his name?" But she wouldn't budge. If there *is* an engineer named Eddie Current, would he please get in touch with us at once? We've a couple of writing assignments we'd like to discuss with him.

COMING NEXT WEEK IN PRODUCT ENGINEERING

. . . **Plating Parts by Peening Them**

Here's a low-cost way to let a tumbler barrel give a corrosion-resistant coating with zinc and other metal powders.

. . . **When You Need Noncircular Gears**

A design guide to most types of such gears. Equations and tables give their basic characteristics.

. . . **Technicians—Answer to the Shortage of Engineers**

Where you find them, the jobs they can handle, how well they are trained.

. . . **Maximum Compressive Stress for Annular Plates**

Labor-saving charts for thicknesses from 0.1 to 1.0 in. and outer radii from 1 to 10 in.

. . . **Designing a Reinforced-plastics Sphere**

A case history in photos—how to hang a 30-ft globe in air on top of a 45-ft building in tornado country; then rotate it (with a hidden drive) at 2 rpm.

COMPACT, RELIABLE, VERSATILE . . .

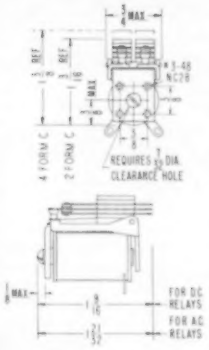
this is P&B's miniature MH relay

The MH is not a new relay.

As a matter of fact, we've been building and selling this series for seven or eight years. Its reliability and exceptional longevity have been proved in business machines, airborne computers and a host of other products.

Engineers like its fast action, its small size, its light weight. They like the wide selection of contact forms . . . up to 18 springs (9 per stack, DC) as well as the fact MH relays can be furnished to switch loads ranging from dry circuit to over 5 amps at 115 volts, 60 cycle resistive.

A multiple choice of terminations add to the MH's versatility. This relay, for example, can be adapted for printed circuits, furnished with taper tabs or a long list of other terminals. Get all the facts by calling your nearest P&B sales engineer today.



MH ENGINEERING DATA

GENERAL:

Breakdown Voltage: 500 volts RMS between all elements.

Ambient Temperatures: −45° C to +85° C. (−65° C to +125° C on special order.)

Shock: 30g on special order.

Vibration: 10g from 55 to 500 cps., .065" max. excursions from 10 to 55 cps. on special order.

Weight: 2½ ozs. max. (open relay)

Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: ⅛" silver standard. Palladium or gold alloy also available.

Load: Dry circuits to 5 amps @ 115V AC res.

COILS:

Resistance: 22,000 ohms max.

Power: 100 mw per movable min. to 4 watts at 25° C max. (200 mw min. to meet max. shock/vibration spec.)

Duty: DC: Continuous. AC: Intermittent (Two pole relay max.) open. Sealed units supplied with full wave rectifier inside can.

Voltages: DC: Up to 110 volts. AC: Up to 230 volts 60 cycles.

The relays below are variations of the MH relay structure.

MA LATCHING
Electrical latch, mechanical reset. Small, versatile and offered with selection of contact arrangements.

MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.

MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

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DEVELOPMENTS TO WATCH . . .

Coming up: new bearing lubes for 1500 F

Solid-film lubricants for controls, gears, bearings and seals—lubricants that hold coefficients of friction below 0.5 at temperatures of 1400 to 1600 F—have been developed at Washington State U Div of Industrial Research, reports Dr. E. N. Klemgard of the division's Engineering Research Section.

With K-78 lubricant, for instance, nickel alloy specimens pretreated with a sodium silicate-lead oxide (Pb_3O_4)-graphite dispersion and cured at 1500 F for 30 min. showed a friction coefficient of less than 0.2 at 1400 F, and only 0.215 at 1600 F—actually lower than the value obtained in the 200 to 800-F range (0.4 to 0.6).

A similar reduction at elevated temperatures was charted with a boron-oxide graphite lubricant. Here room-temperature coefficient was 0.2, rising almost to 1.0 at 600 to 1000 F, and then dropping precipitously to less than 0.2 at 1400 F.

Research is continuing—aimed at improving results with materials already tested and developing even better lubricant combinations for long-term service for high temperatures. Among the most recent developments: solid lubricants that hold the friction coefficient at or below 0.3 over the entire 100-F to 1600-F range.

Hi-temp alloys add vanadium for strength

Nickel-base alloys can be "substantially improved" in stress-rupture and impact properties at temperatures in the 1800-F to 1900-F range, NASA researchers report.

They find additions of 1 to 5% V plus 0.125 to 0.25% C, and 2.5% V plus 2.8% W, provide materials that have stress-rupture lives at 1800 F of 300 to more than 750 hr. This contrasts with less than 50 hr for the basic alloy (Ni-79%, Mo-8%, Cr-6%, Al-6%, Zr-1%). Impact strength of the new compositions is on the order of 62.5 in.-lb; but appears to decrease with increasing V content in some alloys.

Oxidation resistance of the alloys appear to be good. None showed evidence of "catastrophic oxidation" after prolonged testing in air; and all can be cast in air.

The alloys are not, however, more workable than the basic composition. They can be swaged at 2200 F; but reductions accomplished are only on the order of 7-8%.

Soviets have thermistors for the 400 to 1300-F range

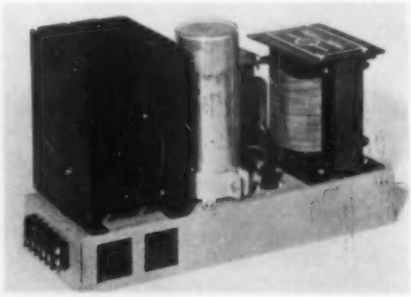
Another outgrowth of USSR research on semiconductor properties of refractory materials (*PE—Jan 18, p 7*) is a silicon nitride thermistor.

It cannot be used at room temperature. Like many related materials (boron carbide, for instance), it does not become a conductor until heated at least to 300 F. But, for elevated temperatures, it rates consideration.

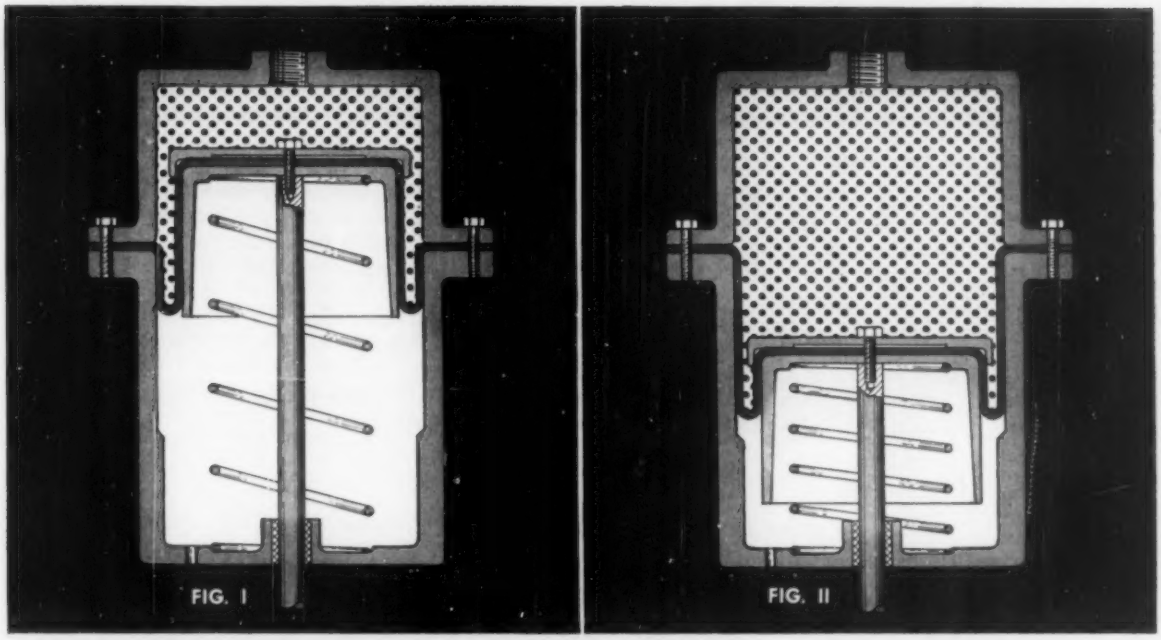
British design controlled-current power supply

A low-voltage power supply for dc amplifiers, exciter lamps in photoelectric devices, and other applications "requiring a compact, stabilized dc source" has been designed by Allied Electronics Ltd, Putney, Eng.

Aimed at applications where batteries are normally used, the unit consists of a germanium junction rectifier circuit, a transistor voltage stabilizer, and a reference potential device. Nominal voltage is 6.3 v at 2 amps. Stability of output with a line-voltage variation of ±10% is 25 milliv. British price: about $75.



DC POWER is mounted on a chassis that's 4 by 10½ x 6¼ in., weighs 7½ lb. Allied Electronics Ltd makes it.



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Nothing rolls like a Bellofram®

Rolling Diaphragm. It's frictionless!

The Bellofram Rolling Diaphragm provides ultra-sensitive response in hydraulic or pneumatic devices where frictionless, long-stroke action in small diameter configurations is required . . . and where flex life of millions of cycles is necessary.

These desiderata are achieved through the *rolling* action of a flexible, thin-sidewall diaphragm consisting of a high-tenacity fabric overlay embedded in elastomeric material.

Fig. I shows how Bellofram Rolling Diaphragm conforms to the piston. Fig. II shows how, as the piston descends under pressure, the Bellofram Rolling Diaphragm *rolls* off the piston's sidewall and onto the cylinder's sidewall in a smooth, continuous, frictionless movement.

The Bellofram principle can be applied widely in actuators, pumps, instruments, seals, accumulators, and fluid dampers.

Which of these advantages are you looking for?

To the designer confronted with situations for which conventional bellows, O-rings, or cup packings are inadequate, Bellofram Rolling Diaphragm offers a constellation of advantages found in no other product:

1. **Friction-free (low hysteresis).**
2. **No break-out friction effects.**
3. **Non-porous and leakproof.**
4. **Constant area in all piston positions.**
5. **Almost infinite flex life (millions of cycles).**
6. **Sensitivity to extremely small pressure changes.**
7. **No mechanical spring gradient.**
8. **Compatibility with practically all environmental gases or fluids.**
9. **Automatic de-icing action.**
10. **Free positioning with complete relaxation at any point in the stroke.**
11. **Does not require close machine finish tolerances on pistons and cylinders.**
12. **Freedom from abrasive wear.**
13. **One hundred stock sizes. Four mounting configurations. Special types and sizes designed to order.**
14. **Excellent temperature stability from —85°F. to 550°F. (from —120°F. to 700°F. in some cases). Wide range of working pressures: 1 inch H_2O to 500 psi (up to 1200 psi in some cases). Effective pressure areas from .028 to 108 square inches. Cylinder bore diameters from .25 to 12 inches. Extended range of stroke (.01 to 12 inches).**

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Please send free literature.

Name.....

Position.....

Company.....

Street..... City..... State.....

I am interested in (*state application*).....

.....

New rubber on the way

Synthetic rubber made from polypropylene oxide is a "likely prospect" for commercial development, says Prof C. C. Price of U of Penna. Discovery of catalyst systems for producing ordered (isotactic) crystalline structures "makes possible the simple, practical preparation of very high molecular-weight polymers" which can be crosslinked to form rubberlike materials.

The same catalyst systems also help convert polyphenylene compounds into materials with interesting fiber-forming and film-forming properties; and these, he says, show promise of having high thermal stability.

Such compounds are under study by several companies both here and abroad, although none appear to have reached the stage of commercial production.

More strength for stainless

The effect of surface treatments in increasing the break-resistance of some high-tensile materials is emphasized by a recent report from Southern Research Institute. In studies there of stainless steel wire for aircraft tow lines, increases as great as 37% in ultimate tensile strength were recorded for electropolished wire as compared to the same material as drawn. In one case, for instance, the original wire, 0.0495 in. dia, showed a unit strength of 276,000 psi. After reduction in dia to 0.023 in. by electropolishing, its ultimate tensile strength was 374,000 psi.

Surprisingly, the same treatment seemed to have little or no effect on carbon steel wire of approximately the same size and type.

Metals can make metals burn

Alloying may increase susceptibility of zirconium to ignition, Argonne National Laboratory researchers report.

In studies of oxidation kinetics of this active metal, they found ignition was independent of pressure, and burning proceeded according to the cubic-rate law over the full temperature range from ignition to 1650 F.

But when such alloying elements as Ti, V, and Sn are added to zirconium—even in fractional percentages—the picture changes considerably. In most cases, burning no longer follows the cubic-rate law; and ignition temperatures—in both oxygen and air—drop as much as 100 degrees. Of 20 alloying elements tested, only Ni, Cu, Be, and Hf seemed to avoid this adverse effect.

The oxidation curves for the other alloys show a distinct transition or "breakaway" point at which the log plot—of oxygen consumed, against time in minutes—turns sharply upward. The breakaway seems most pronounced with those additives which most seriously affect ignition rate.

The explanation? The researchers note that pure Zr quickly acquires an "extremely protective" oxide coating when heated in an atmosphere of flowing oxygen. Ignition does not occur, even at temperatures above 2300 F under these conditions. Apparently the additives interfere with formation of this protective film or alter its character so that ignition occurs more readily and burning proceeds faster after a critical temperature is reached.

Argonne has prepared two reports on this work (ANL-5974 and 6046), to be available from OTS, Dept of Commerce, Washington 25, DC.

Better carbide parts for structural use

Improved fabrication methods are expanding the structural applications for silicon carbide, says Carborundum Co. Its product list now includes valves, tubes, nozzles, blades and bearing seals for heat exchangers, sprayers, pumps, motors and stators.

Relatively complex shapes can be held to 0.010 in. as-pressed and ground to ±0.002, with a 35-microin finish. Furthermore, the material can be supplied in a structure dense enough to prevent leakage through tubing walls $\frac{1}{8}$ in. thick at 4500-psig hydraulic pressure; and to provide $\frac{1}{4}$-in. tubing that is gastight to helium at temperatures to 2500 F at 15 psig.

—ARG

WHAT'S HAPPENING IN RESEARCH . . .

Devices that speed high-speed testing

A new family of testing devices is being developed by Fabric Research Laboratories, Dedham, Mass,—specifically for testing plastics and textiles, but with much broader potential application. The aim: to study the stress-strain behavior of materials at higher than normal rates of loading—to 2000 ft/sec.

One, developed jointly with Celanese Corp, exerts a pull—pneumatically—on the test fiber while a piezoelectric-force transducer puts out a proportional, measurable signal that is picked up and displayed on an oscilloscope, permitting calculation of a stress-strain curve. It's set to allow loading rates up to 15 ft/sec—many times that obtainable with conventional electronic strain machines and other testing devices.

Another, now under construction for the Air Force, is a large ballistic apparatus that literally shoots projectiles 8 in. long and 2½ in. dia at large material samples at a speed of about 600 ft/sec, and records the results photographically.

No plans have yet been made for commercializing the machines. At present, they simply represent an effort to meet the needs of FRL's current projects.

"Tired" phosphors? These scientists say "yes"

Evidence that electroluminescent phosphors exhibit fatigue characteristics under constant operation was presented by S. Nudelman and J. Mudar of U of Mich at the recent American Physical Society meeting. This might put a caution sign on some proposed applications for this new lighting technique (*PE—Sep* 15, '58, *p* 74).

Surprisingly, mechanical agitation of test cells restored properties to some extent, though the benefit decreased as the action was repeated.

The fatigue effect has been observed at frequencies to 6 megacycles/sec, with applied voltages on the order of 1500 v, and at temperatures down to those of liquid nitrogen. Furthermore, fatigue accelerates with increasing frequency. At 2 mcps, a loss of 10 to 25% in light output occurs within 30 min.

Polymers as semiconductors?

Organic resins and plastics can be made to exhibit true semiconducting properties—just like germanium and silicon—says Soviet Academician Alexander Topchiev. By subjecting acrylic resins to ionizing radiation (on the order of 4.5 million roentgens), he says, stable electrically conductive materials can be produced. Both polyacrylonitrile and silicon-acrylonitride types are now under test at the Institute of Semiconductors in Leningrad.

This is not the first time semiconductor effects have been observed in plastics—produced either with or without radiation. The important thing about the Soviet announcement is its claim for stability of the materials after irradiation—permitting their use as design elements. Most previously reported materials were unstable either chemically or in their semiconductor properties.

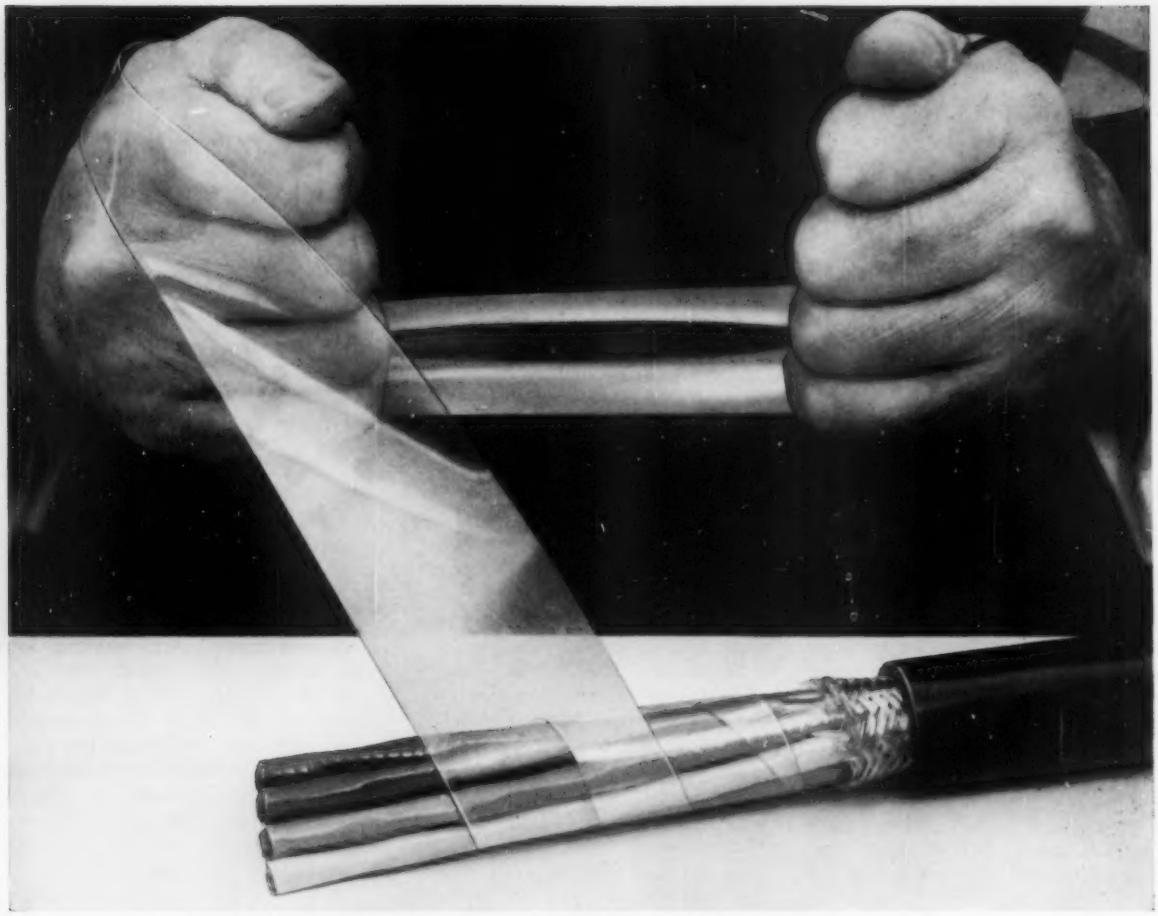
New light on the oldest engineering material

It looks like a metallurgical test—of high-tensile wire, perhaps. Actually, the picture at the right shows one phase of a major effort at Washington State U to determine the mechanical properties of individual wood fibers and provide new data for predicting the properties of products made from wood fibers and pulp—among them, papers for insulation, lamination and other engineering uses. (*PE—Feb* 16, '59, *p* 50).

Dr B. A. Jayne of Washington State says tests have already shown inherent differences in load-deformation relationships of early- and late-wood fibers (the "early" fibers—those formed during the spring—being, in general, weaker than those formed later in the year) and have uncovered "a limit of proportionality between stress and strain which indicates that wood fibers possess viscoelectric characteristics. He notes, too, the similarities between wood and textile fibers, pointing out that many tests developed for these and other fibers (see above) should be applicable to wood.

As to specific results, early-wood spruce and cypress fibers showed average tensile strengths of 70,000 to 80,000 psi; proportional limits in the 40,000 to 50,000 range. For late wood, average tensile strengths were 82,000 to 144,000; proportional limits 58,000 to 73,000. —ARG

WOOD FIBERS get load-deformation test in this machine at Washington State. Late-wood fibers show proportional limit nearly twice that of early wood; and differences between early and late wood are often considerably greater than variation between tree types.



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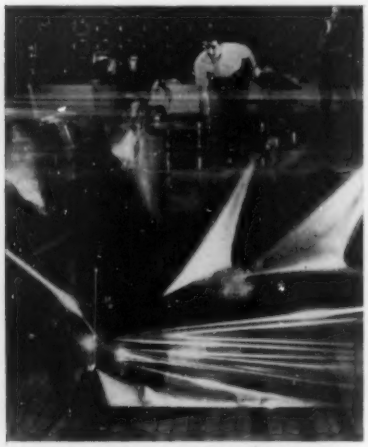

Tensile strength of 20,000 psi . . . Bowling-ball test offers dramatic proof of the amazing strength and toughness of "Mylar" polyester film.

"Mylar"* polyester film is a tough, flexible engineering material. Used as a core binder tape for electric cable, "Mylar" prevents sharp braid wires from puncturing the primary insulation during cable manufacture. Replacing heavier, thicker materials formerly used, "Mylar" reduces size, weight, cost of cable.

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On an area basis, tough, thin "Mylar" often costs less than heavier, conventional materials. "Mylar" can be laminated, embossed and metalized, punched or coated. The film won't become embrittled with age. "Mylar" is available in roll or sheet form in a wide range of gauges.

Find out how the combination of properties in "Mylar" can help you solve knotty design problems, improve product performance or cut costs. Write today for our new booklet containing detailed information on properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Room P-3, Wilmington 98, Delaware.

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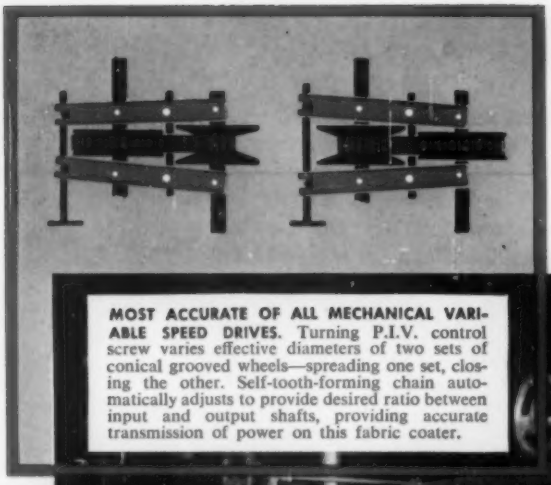

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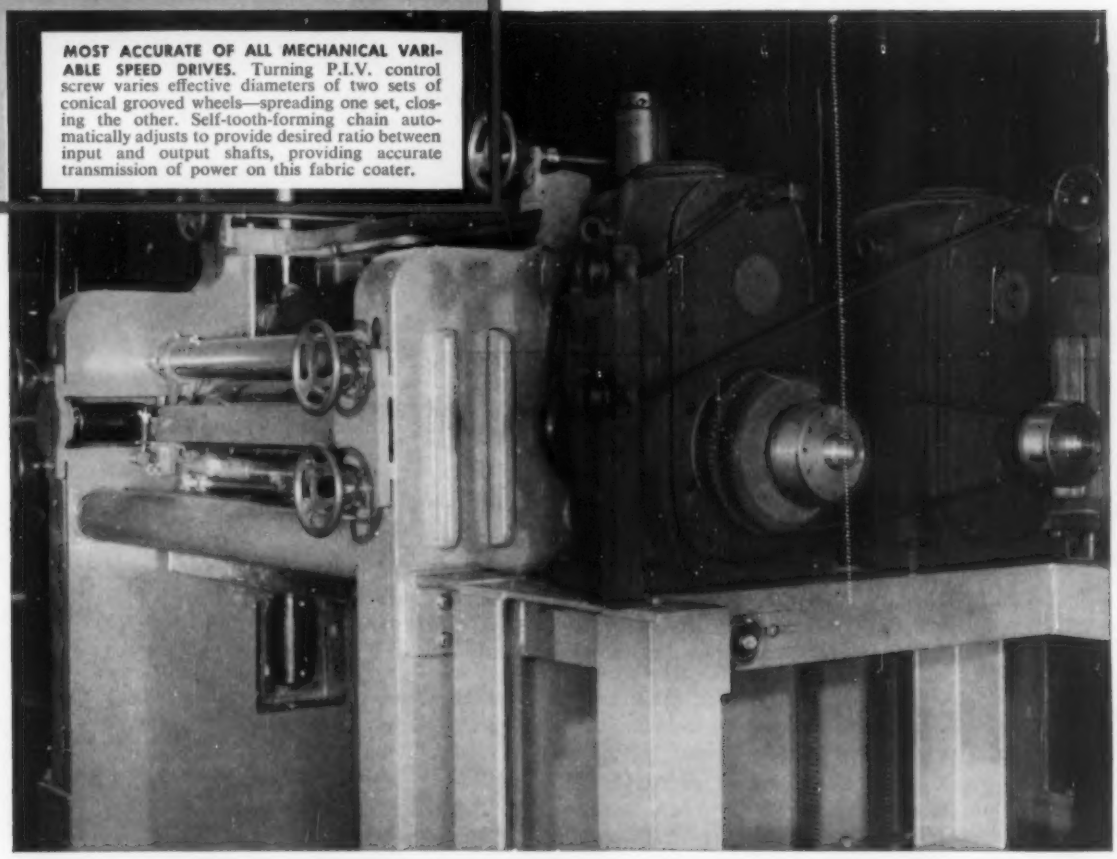

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FROM WASHINGTON . . .

Slow-flying airplane in the planning

The Air Force has plans for a new airplane. The secret project—dubbed Dromedary—is still in the study stage. **But Air Force planners say the plane may become the bomber of the future.** The Rand Corp is directing the study, with reports that Boeing and Northrop are involved.

To be a long-endurance, slow-flying craft, the plane's main purpose would be to serve as a launching platform for ballistic missiles. Predictions, as of now, are that the plane could be kept in the air for as much as 10 days without refueling.

Endurance would come from using a perforated "laminar-flow" wing to reduce drag and thus cut fuel requirements. Air Force spokesmen are openly optimistic about the possibilities of the craft. It could be built, they say, with conventional components and not need any startling breakthroughs in technology to be successful. Power would come from conventional jet engines burning existing fuels.

Cost of the airplane would be relatively cheap compared to the B-70 bomber and nuclear planes under development. As such, the service's top brass thinks it could sell the Dept of Defense and Congress on the program. Results of the study won't be complete for several months, most likely not in time to go to Congress for additional money this year.

Rocket engines outgrow thrust-measuring devices

Thrust measurement of the big superbooster rocket engines is a problem. And it is increasing as development of the larger boosters goes on. **Right now, for example, the highest thrust that can be measured on a direct deadweight basis is 111,000 lb.** But rocket engines for the Atlas and Titan ICBM missiles already surpass that. **And boosters under development are in the 1-million-lb thrust class.**

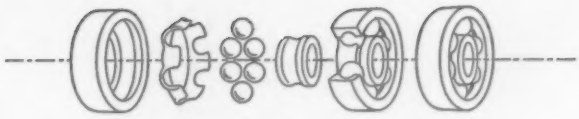
This is one reason for the Bureau of Standard's rush to build its 1-million-lb deadweight machine. Virtually all of the rocket engines used in space experiments today must be thrust-tested with indirect load cells. After almost all shoots from Cape Canaveral, these load cells are flown back to the Bureau of Standards for an accuracy check. The reason, particularly in the case of firing failures, is to see if the engines were actually producing the thrust they were programmed for.

Inaccurate thrust measurements cut down on payloads carried and can mean success or failure for experiments. For the 1.5-million-lb thrust Nova rocket booster that will be used for deep space experiments, present facilities can only measure its thrust to 0.10%. The rocket developers, however, need this refined to 0.05% accurate. The Bureau of Standards, meanwhile, expects to have its new calibration facilities completed by the time the Nova rocket is developed.

Air Force anxious to launch missile-alarm system

A top-level decision is in the making now to start the first operational satellite system. The Air Force is plugging hard to win Dept of Defense approval to launch a series of Midas (missile identification detection and alarm system) satellites.

The satellite uses an infrared system to spot missiles as soon as they are fired. Air Force claims the system has been developed sufficiently to put it into operation—and that it will double the warning time for the US if the Russians launch a missile attack. Right now, our present warning system will give only a 15-min. notice of incoming missiles. Air Force says Midas will increase this to 30 min. Cost of the system may be a deterring factor; a decision is expected shortly.



MEASURING ROUNDNESS OF INSTRUMENT BALL BEARINGS

By **RICHARD E. AMIDON**, *Staff Engineer, Production Engineering Department*
New Hampshire Ball Bearings, Inc.

Roundness of instrument ball bearings is a variable not covered by ABEC standards. Yet, it is an important factor in running quality. Since it is a very difficult variable to measure, except with costly equipment, most users must accept roundness on faith.

Roundness can be defined as "equidistance of all points on a curved surface from a fixed center". To measure roundness of a ball bearing component, therefore, you must establish its center and radius. However, since its center is not accessible as a point of reference, you must establish an "artificial" center. The closer the assumed or artificial center is to the actual center, the more accurate a given method of roundness measurement will be.

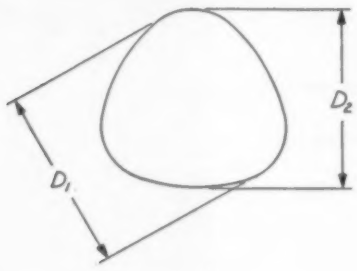
What you're really measuring is out-of-roundness, or deviation from a true circle. Such deviations are called lobing. There are three common ways of measuring out-of-roundness.

THE TWO-POINT METHOD

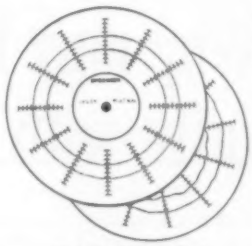
Most widely used of all measuring techniques is the method of measuring various diameters between two anvils as in a micrometer or two-point gage. The difference between the largest and smallest diameter is out-of-roundness. This method is accurate only if there is an even number of lobes of equal height and symmetrical spacing. Notice in the accompanying sketch of a three-lobed shape, all three diameters are equal . . . and the two-point method would indicate perfect roundness.

THE THREE-POINT METHOD

When an odd number of lobes exists, a three-point gage can be used to measure out-of-roundness. Variations are measured by rotating the part between two fixed points at a known angle with each other and a movable point connected to an indicator. This method, which calls for calculations to convert indicator readings to true-out-of-roundness, is accurate only when the number of lobes is known and they are symmetrically spaced and equal in height.



ELECTRONIC GAGING



POLAR CHART TRACE

Fortunately for you, instrumentation has been recently developed which measures out-of-roundness directly as radial variation with accuracy to several millionths of an inch. The part to be measured is chuck-mounted to a precision spindle and slowly rotated. An electronic gage head translates radial surface variations into a polar chart trace with deviations magnified as much as 10,000 times. Comparison of the chart trace with concentric circles of known radii reveals absolute deviation from a true circle. New Hampshire Ball Bearings, Inc. was the first to use this instrument as a quality control tool in the laboratory and on the production line. Other instrumentation used to assure the running quality of New Hampshire Bearings is described in our new Design and Purchasing Manual.

NEW DESIGN MANUAL

Newly revised and expanded, this authoritative publication covers everything you need to know about applying and buying miniature and instrument ball bearings. Comprehensive general information, catalog data and engineering bulletins are included in its 100-plus pages. Personally registered copies are available to qualified engineers, draftsmen and purchasing agents. Please send your request on your company letterhead.

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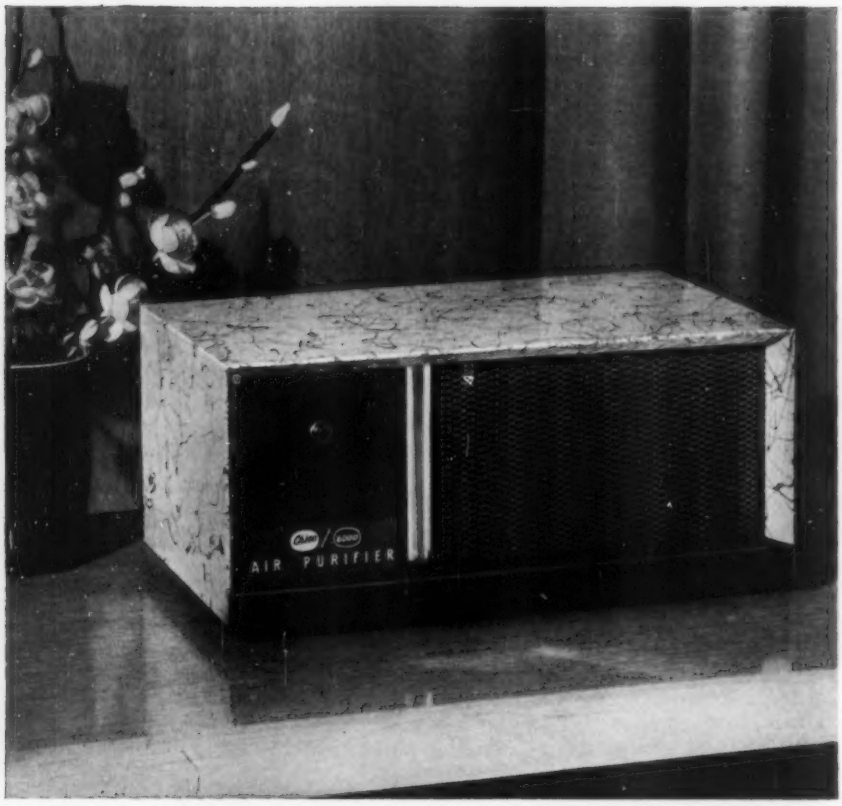

Chico air purifiers are made by Chico General Products Corporation, Burlingame, Cal. Penn Metal Company's distributor, Tayler Products Corporation, supplied the expanded metal.

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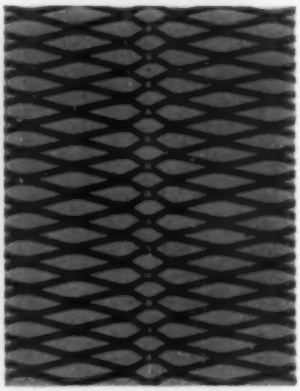

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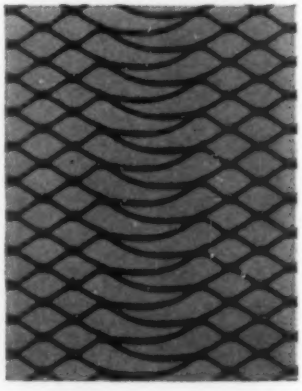


US Designer Carries Survival Warning to European Industry

Peter Muller-Munk, eminent US industrial designer, is beginning a series of seminars throughout Europe, aimed at giving European industrialists the background they need to meet the challenge of the new mass markets. His tour is sponsored by the Organization for European Economic Cooperation. Before leaving, Mr. Muller-Munk gave Product Engineering a preview of his frank message.

Peter Muller-Munk

NEW YORK—"Industrial design is the consumer's voice in management . . . and too few European companies have been listening carefully enough."

So says US industrial designer Peter Muller-Munk, who is beginning a series of seminars on his specialty, to be held throughout Europe during the next 13 months. Paris is the first stop on a schedule that will also take him to Norway, Denmark, the United Kingdom, Belgium and Ireland during the next four months. Thereafter, the tour, sponsored by the Organization for European Economic Cooperation, will cover other countries that submit requests. (*For other OEEC projects see PE—Jan 11, p 15.*)

Before he left, Muller-Munk predicted his hardest task will be to convince Europeans that industrial design is not an American luxury.

"Industrial design, as I define it, is seldom encountered in Europe," he believes. "England has some good industrial designers, and you find a few in Scandinavia and Italy. But, by and large, this is a new concept for Europe—and one that must be grasped soon if European industry is to survive.

Free Europe has a heavy stake in the consumer, Muller-Munk stresses: "These nations have divided into two large trade blocks—the Common Market and the Outer Seven—which, I feel, will eventually merge. Members of the blocks have agreed to eliminate tariff barriers in commerce within their own areas. This agreement opens the way to mass markets that will encourage high production. But the European dream of high production will come to nought unless consumers buy the products."

In Muller-Munk's view, industrial design has life-and-death implications for the individual manufacturer—as tariffs vanish, insularity also vanishes. But, the American says, "European manufacturers have too often found it convenient to continue traditional practices. Now, they must adapt to the conditions of mass markets, and design the products that people want. Many firms will go under, but many others will profit enormously."

Another lesson he hopes to teach is that "industrial designers should be responsible to the top person in the company. Too often, industrial design is mistakenly viewed as a phase of engineering, sales, marketing, or some other corporate function."

"Europeans today," he concedes, "have many fine stylists who are creating products with great esthetic appeal—heavy equipment as well as consumer goods. To me, many of the Swiss milling machines are quite thrilling. Each part is impeccable, right down to the final clean-cut package. But a good stylist can give little guidance on markets, distribution channels, or the design that will achieve best performance at a price the consumer can pay. These functions need their own specialists.

"Europe's economic transformation will create many problems in making products attractive to the consumer. For example, many Italians are now moving north into Germany and other industrial centers where labor is short. These migrants carry along their accustomed cultures, and, of course, want to eat their traditional foods. But if the German food processor hopes to sell to the new arrivals, he must pay close attention to the color of his package, for the Italian reaction to color is quite different from the German."

After the first four months of the assignment, Muller-Munk will be relieved by Paul Karlen, director of overseas projects for Peter Muller-Munk Associates, who will carry the seminars through early 1961. Muller-Munk will then return for concluding sessions in February and March, next year. During his initial tour, Muller-Munk will have the assistance of two Europeans. One is Gunner Brynge, technical director of the Swedish firm, Husquzarna.

Seminars will cover all aspects of industrial design: definition, relation to styling, integration of distribution and sales, short- and long-term product planning, industrial design in consumer and engineered (industrial) equipment. He will also touch on such questions as whether a company should hire a consultant or set up its own industrial design department; whether corporate identity is important and, if so, how a company achieves it.

The seminars will be basically identical in each country, though there may be some adaptation to fit the industrial composition of the host nation. Muller-Munk will spent several weeks in each country, the exact duration depending on the number of seminars he is asked to give.

Although he would not predict the outcome of the seminars, Muller-Munk pointed out that Europeans are keenly interested in industrial design. "It is not being forced upon Europeans; they're asking for it," he said.

The OEEC asked him to give the

seminars, and advised member countries of the impending lectures.

The seminars are being financed from OEEC funds, which are obtained from an annual assessment of member nations.

The audiences will be drawn from top ranks of industrial management. Some university personnel may be present. If so, the seminars could conceivably stir enough interest to start design courses at the universities. ■

Will Space Knowledge Help Design Engineers?

NEW YORK—Is design work in the fields of space vehicles and atomic energy going to have an effect on everyday products? The answer to this and many other engineering problems may be answered by 35 design authorities at the forthcoming ASME Design Engineering Conference at the NY Coliseum, May 23-26. Besides the 4-day conference, approximately 400 nationally known companies will exhibit at the Design Engineering Show, produced by Clapp & Poliak Inc, New York exposition management firm.

The theme of the conference, "New Horizons in Engineering Design," will be set by the opening-day panel of outstanding design authorities from the space and atomic field. They include: Dr Hugh L. Dryden, National Aeronautics and Space Administration; Dr Arthur R. Kantrowitz, Avco-Everett Research Laboratory; William R. Gall, Oak Ridge National Laboratory; Varick D. Schwartz, Combustion Engineering Inc; George P. Sutton, Advanced Research Projects Agency; and Elmer P. Wheaton, Douglas Aircraft Co.

A panel session on the final day will consider the problems of computers; types available, which ones to use for specific engineering problems, cost of installation and operation, and training of personnel. Experts from Socony-Mobil Oil Co, Worthington, General Electric, General Motors, and Republic Aviation will participate.

Concurrent sessions on Tuesday and Wednesday will consider reliability, control systems, fabrication, high-strength steel and composite materials, hydraulic systems, and automation. ■

Ford Designing Levacar as Replacement for RR

DETROIT—Ford's well-known Levacar project (*PE—June 15 '59, p 23*) shows signs of becoming a reality with the announcement of plans to adapt it for operation on rails of conventional design. The ultimate aim for this air-supported vehicle is to provide public transportation at 200-500 mph between so-called "Golden Triangle" areas such as Washington, Pittsburgh and New York, or Cleveland, Detroit and Chicago.

Travelers between these points are now faced with marginal conventional rail service, or the alternative of spending one hour on either end of a one-hour flight by air. This latter schedule, of course, assumes good weather. The fact that airports in each of these cities maintain schedules within 90% of maximum capacity lends substance to Ford's approach. Bad weather or equipment trouble can add hours to current air travel time.

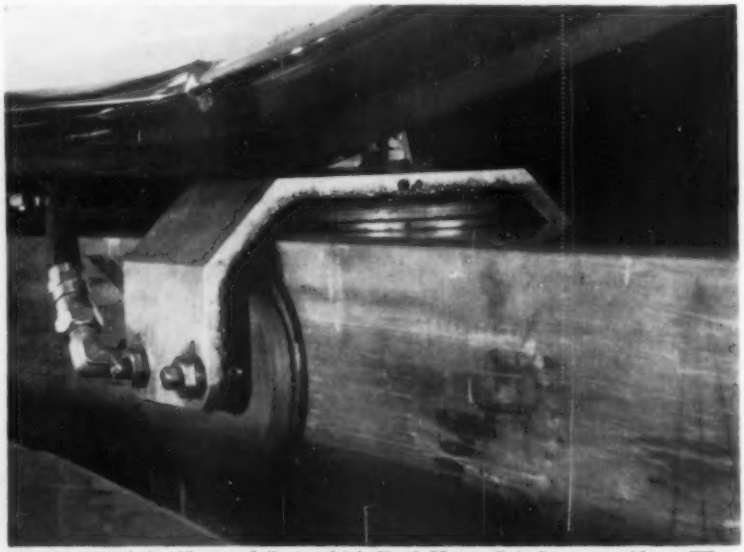
According to project engineer David J. Jay, Ford is about to approve a significant expenditure for a full-scale Levacar proving ground. It will include an oval roughly 10 miles in diameter to achieve speeds envisioned as practical for the vehicle. It will also mean building prototypes that can carry a payload.

Wingless, air-supported vehicles presently fall within three categories: those lifted by reaction to a jet; those supported by a blanket of low-pressure air; and those, like the Levacar, that run on a thin film of high-pressure air. The first group includes VTOL aircraft; the second, air-cushion vehicles like Curtiss-Wright's "Air Car"; and the third are those supported by a film of air, 15 to 30 thousandths of an inch thick, at 15 to 100 psi. These latter are "high pressure" only by comparison with the air-cushion variety which levitates at about 0.1 psi.

Ford planners, headed by Jay, expect to use existing railroad rights of way for reasons of economy. Overhead structure to support the vehicle sounds most reasonable at this time, to avoid grade-crossing problems. Also in their minds, though, are the possibilities of using meridians of expressways or even highways.

Jay has had numerous queries from

Rails to Guide Levacar



Here's one of the "levapads" on which Ford Motor Co's Levacar rides. When vehicle is in motion, levapads hold car a fraction of an inch away from top and sides of the rail, permitting it to slide on a thin film of air at speeds from 200 to 500 mph. The first experimental Levacar designed to use rails for guidance, can attain speeds of 20 mph on a 30-ft dia circular track.

major railroads and welcomes more. Although travelers are aware by now that railroads have all but written off the possibility of profit from conventional passenger traffic, there still seems to be interest in a dramatic revival via a breakthrough such as the Levacar.

Although strictly speculation, the first installation could be outside this country. One possible project is providing rapid transit in Brazil between Rio de Janeiro and Brasilia, the new capital city being built some 600 miles away. Another is linking Montreal, Quebec and Toronto. Both instances involve government financing.

The ultimate Levacar is envisioned as a 40-passenger vehicle that weighs less per passenger carried than an aircraft. Gross weight would run around 28,000 lb, requiring 700 hp for levitation. To propel it at 100 mph would require only 40 more horsepower, according to Jay's calculations. However, propulsion horsepower increases by the cube of the velocity, so a speed of 400 mph would require 3260 hp for both propulsion and levitation. Nevertheless power requirements are well within the capabilities of existing, commercially available gas turbines.

The free-piston engine at first seemed attractive because of readily available, excess compressed air. But this, according to Jay, is a touchy, unproved design. Gas turbines are currently favored because it is easy to design an oversize compressor and bleed it to operate the "Levapads," Ford's name for the running surface.

The possibility of power failure, and consequent loss of air support, is not considered serious. The vehicle would merely set down on its pad and skid to a stop, and, calculations show, in less distance than that required by a conventional train. The cold-steel rails would prevent disintegration of the pads.

Progressing from the toy scooter, powered by a stationary compressor, to the designs envisioned today, involved solving serious vibration problems. These are the subjects of patents pending, but Jay says that "it was primarily a matter of the shape of the pads."

His group developed a special method of calculation that eliminated much of the trial and error in locating the air outlets in the contours of the pad. —Don MacDonald

Build-it-yourself Helicopter

Powered by a modified 60-hp Mercury outboard engine, the Benson Aircraft Corp's "Little Zipster" cruises at 60 mph and has a 100-mi range at 700-lb gross weight. Useful load is 250 lbs. It's priced for export at $6995, FOB factory. Basic construction drawings sell for $5. Airframe consists essentially of three straight tubes bolted together for quick assembly and disassembly. No welding or brazing is used in the primary structure. Last stage of the transmission is a chain-and-sprocket drive—similar to that in a motorcycle. Except for high-strength AN aircraft bolts, all other materials are of commercial quality.

Stronger Al-Mg Alloys with New Tempering

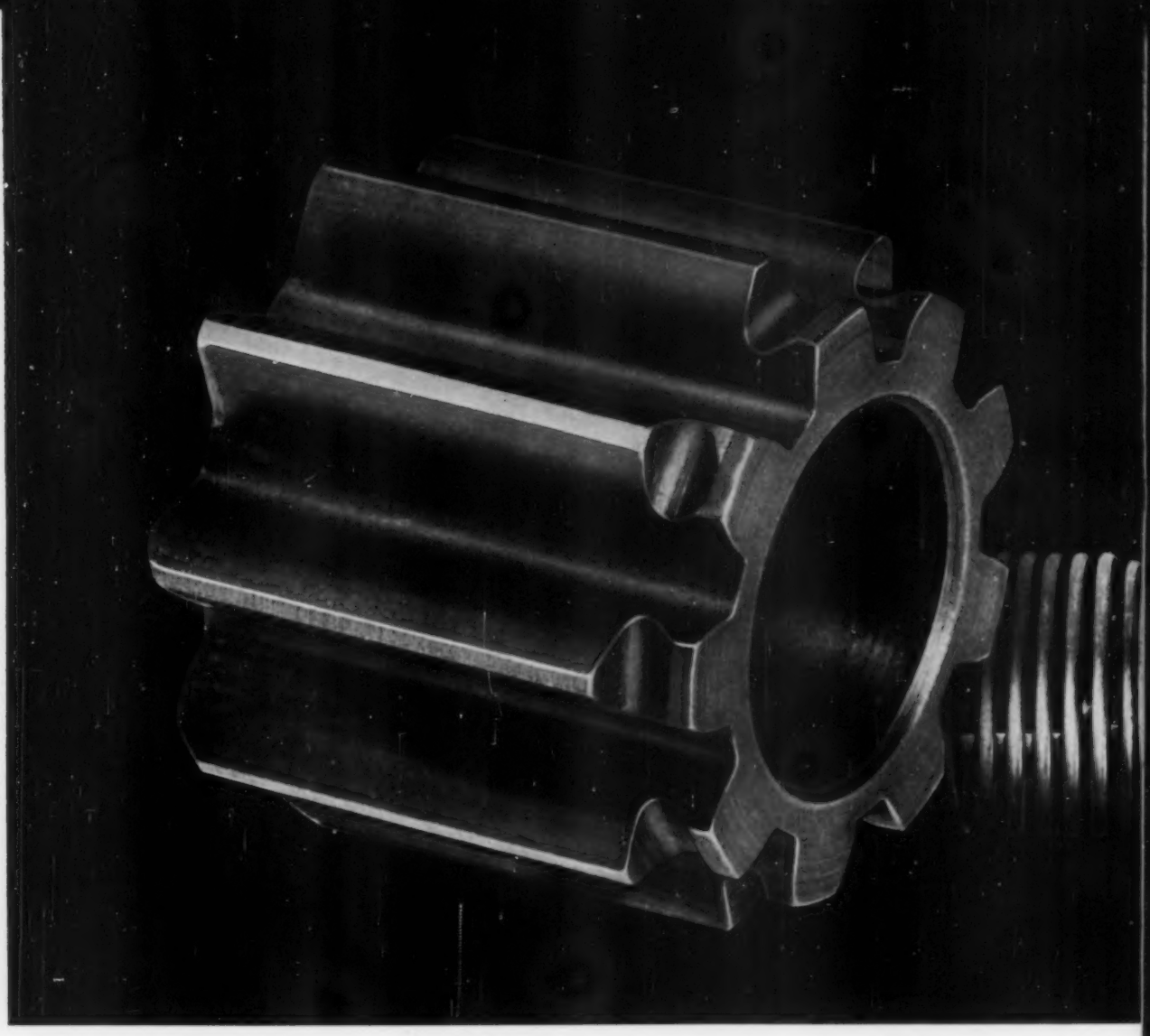
PITTSBURGH—Strength and reliability of the aluminum-magnesium alloys used in highly stressed products, ranging from boat hulls to ballistic missiles, have been increased by a new tempering process. According to Alcoa, the process makes possible two new tempers—designated —H323 and —H343—giving maximum resistance to stress corrosion for sheet in alloys 5456 and 5083.

High properties previously were obtained in 5083 sheet by cold-working the metal to the —H32 and —H34 tempers an Alcoa spokesman explained.

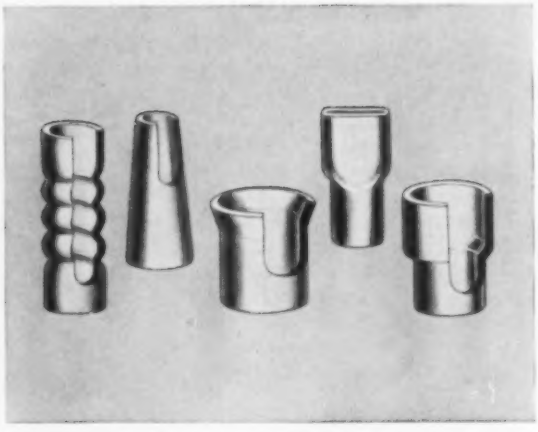
continued on page 20

Minimum Properties for New Tempers

Temper	Gage, in.	5083			5456		
		T.S., ksi	Y.S., ksi	Elong., %	T.S., ksi	Y.S., ksi	Elong., %
—0	0.126–0.750	40	18	16	42	19	16
	0.751–2.000	38	16	16	42	19	16
—H321	0.126–1.250	44	31	12	46	33	12
	1.251–2.000	44	31	12	44	31	12
—H113	0.126–2.000	44	31	12	—	—	—
—H323	0.126–0.249	45	34	8	48	36	8
—H343	0.051–0.125	50	39	6	53	41	6
	0.126–0.249	50	39	8	53	41	8
—H24	0.051–0.249	—	—	—	51	39	9



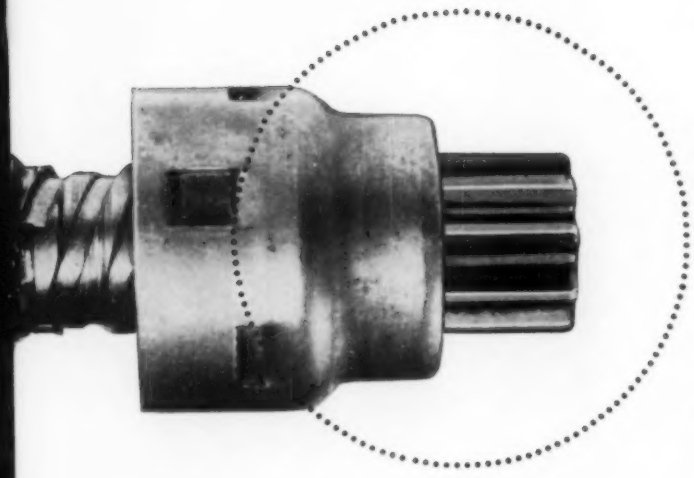
ONE-PIECE SHAPES REPLACE COSTLY ASSEMBLIES when Republic Cold Drawn Special Section Bars formed to the predominating cross section of the part are used. Completed parts are stronger, longer wearing, and cost less. Republic Special Sections simplify built-up, interlocking, or associated parts . . . are available in carbon, alloy, and stainless steels.



SIMPLIFIED TUBULAR PARTS PRODUCTION results from use of Republic ELECTRUNITE® Mechanical Tubing. With uniform wall thickness, concentricity, strength, and ductility, ELECTRUNITE Round Mechanical Tubing is easily flanged, swaged, flattened, spun, fluted, configured, rolled, upset, and otherwise changed in cross section. Mail coupon.

CIRCLE 18 ON READER SERVICE CARD

SOLVING THE PROBLEM



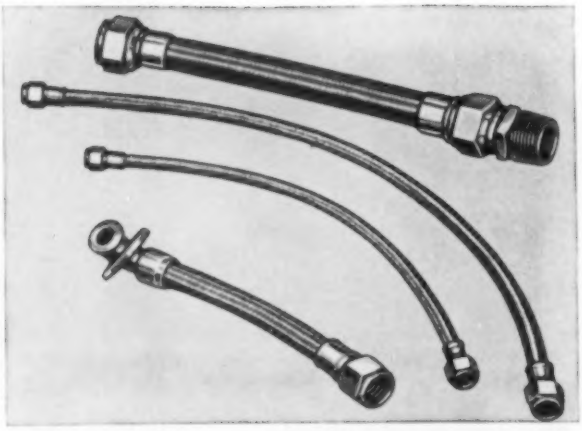
Alloy steel starter drive pinion withstands severe torque, impact, wear

One of the largest manufacturers of automobile starter drives specifies Republic Cold Drawn Alloy Steel Bars for their most critical component—the drive pinion.

Following delivery, the cold finished alloy bars are blanked, hobbed, chamfered, and drilled. Teeth are cut on a gear hobber, then pointed for easy meshing with the flywheel.

Use of Republic Alloy Steel provides the necessary strength and toughness to withstand torque, impact, and prolonged wear. In addition, the cold drawn alloy used provides better machinability at reasonable cost.

Republic field metallurgists will work closely with your metallurgists and engineers. 3-Dimensional Metallurgical Teams, comprised of field, mill, and laboratory metallurgists, will help you select, apply, and process the right alloy steel for any application. Write today or mail the coupon for complete information—without obligation—on this confidential service.



HIGH PRESSURE FITTINGS—sockets, nipples, flanges, elbows, and swivel nuts—to handle missile and aircraft fuels are produced by Resistoflex Corporation, Roseland, New Jersey. Fittings are machined from 3/16" and 2" diameter Republic Stainless Steel Bars to assure maximum strength, corrosion-resistance, and machinability.

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Continued from page 17

The amount of work imposed increased the alloy's susceptibility to stress corrosion. A similar situation existed with alloy 5456, although to a lesser degree. The new tempering procedure gives maximum assurance of resistance to stress corrosion, without sacrificing the high-strength properties obtained by cold working.

In the new –H323 temper, alloy 5456 now exhibits a 4% increase in minimum tensile strength over any previously available. Minimum tensile properties are indicated by the accompanying table (p 17). ■

New Insulation Highlights Patent Show

WASHINGTON—Some 18 major US companies have joined the Department of Commerce Patent Office here for the fifth annual exhibition of chemicals and synthetics. The show's theme is "Science, Industry, Invention and the Patent System." It will be followed by a similar exhibit on mechanical engineering (May 9—June 3) and electronics (Oct 17—Nov 11). Participating companies display technical progress they have made under the American Patent system.

Some relatively new companies, with products only recently on the market, have joined in this salute to the Patent Office. One of them, US Insulation Corp of Carson City, Nev, nearly stole the show with its Thermo-K insulation. The material consists of disintegrated newspapers treated with boric acid. To demonstrate its heat-resistant properties, company officials seared a handful with the 4000-F temperature of a Presto-o-lite torch. When the torch was removed, there was not even enough residual heat in the material to ignite a match.

In addition to resisting heat, Thermo-K is guaranteed by its manufacturer not to pack or deteriorate. It weighs approximately 75% less than competing insulators and is competitive in price, the company says.

Although aimed initially at the home-building market, the insulation is expected to have applications in a variety of industries. A Los Angeles inventor is working on a process that would adapt it to an automobile exhaust control device. Steel companies have reportedly shown interest in it for fabrication purposes. US Insulation, itself, is exploring possibility of its application in truck trailers.

Although the original patent for the material was granted 11 years ago, the first production plant opened in Houston this January. Four others are in the planning stage.

DEMONSTRATING HEAT RESISTANCE of new insulating material here is Charles Toce, executive vice-president of US Insulation Corp. He's melting a penny on handful of the material called Thermo-K, which remains unaffected by heat. Looking on is Philip A. Ray, Under Secretary of Commerce.

OTHER FIRMS EXHIBITING

Among the other exhibitors at the show were DuPont, National Lead, Metal & Thermit Corp, and Food Machinery & Chemical Corp. Another, General American Transportation Corp, cited the worldwide use of its Kanigen process for chemically plating metals with nickel as an example of the benefits of protection offered by the patent system.

The patent office has issued nearly three million patents since it was founded in July 1790. An estimated 350 patent applications are being received each working day, the agency reports. ■

Mitey Mike Records Jet Noise

The tip of this tiny device (less than 1 in. long) is a microphone about the size of a letter of type printed on this page. It is used by scientists at Massachusetts Institute of Technology to study noise of jet aircraft and rockets. Streams of air are run at known temperatures and pressures, then microphone is used to pick up additional sounds caused by flow instability. Study is sponsored by the National Aeronautics and Space Administration.

Soviets Spur French Machine-toolProduction

PARIS—Automatic copying lathes, built mainly from modular parts, will be produced at a rate of 25 a month by the end of this year. Explaining this pace it has set for itself, a large French manufacturer of machine tools says the machines will be built on a common basic unit with about 50% modular components.

Priced well below that of any comparable tool produced in Western Europe, the new lathes are to be produced as a result of a recent tour of Soviet machine-tool plants by a group of the company's executives. These executives concluded that mass production of machine tools is the only answer to an invasion of world markets by low-cost Soviet tools.

However, company spokesmen admit that, despite this stepped-up production of copying lathes at competitive prices, Western Europe has a long way to go before matching Soviet production of machine tools. ■

Money Lures Engineers to Industry Jobs

ANN ARBOR, MICH—Money is the main—but not only—reason engineering teachers leave college for industrial positions. This statement by A. R. Hellwarth, assistant dean of the Univ of Michigan College of Engineering, is based on a survey of 235 teachers, from 77 colleges, who switched to industry.

TEACHERS' PET GRIPES

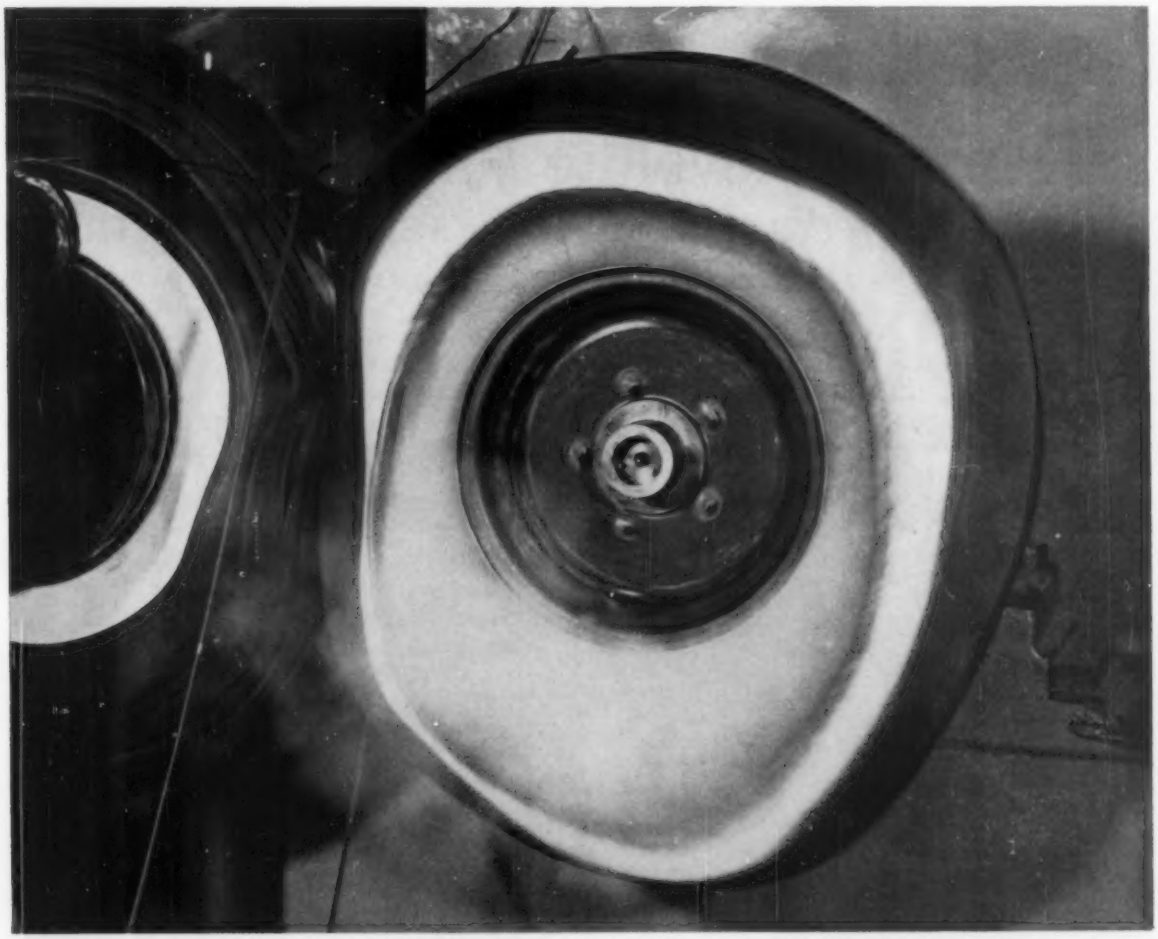
Aside from salaries, primary complaints of the former teachers were: dissatisfaction with teaching loads; onerous administrative details; and personal gripes against the college or its administration.

But for 116 of those queried, income and fringe benefits of industry were deciding factors. Their annual salary had averaged $5800 in teaching —or $7650 with summer jobs and consulting fees added. During their first year in industry, these engineers averaged $9800.

On fringe benefits, they compared industry's better retirement, insurance and travel allowances with education's better vacations.

Though tangible inducements of industry now outweigh the intangibles of teaching, 195 said they hoped eventually to return to campus after gaining practical experience or a financial backlog. The appeal of campus, these engineers say, is "the satisfaction of teaching and the feeling that one is doing something of value for the society he serves," and "academic freedoms and time freedoms of the campus." ■

Test Tortures Tires

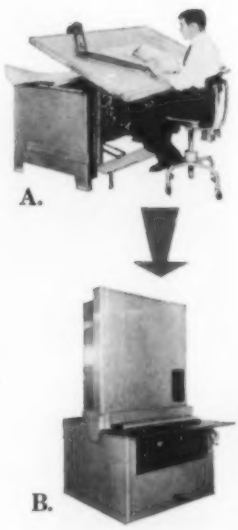


It's hell on wheels when Goodyear Tire & Rubber Co's $2-million multi-stage dynamometer test goes to work on jet-aircraft and racing-car tires. In this new "tire-on-tire" test facility, two tires are pressed together, tread to tread, to duplicate actual load conditions. Tires are then driven at surface speeds exceeding 500 mph. Tire at left, which survived, shows strain imposed on its carcass and tread. Tire at right is leaving the rim as its bead yaws from the wheel. Second unit of the test system consists of a flywheel, 10 ft dia, with a tire carriage on each side. It is used primarily for testing aircraft tires, and is capable of achieving surface speeds of 320 mph in less than 20 sec. Flywheel test can accommodate loads of better than 80,000 lb and tire sizes from 16 in. to 6 ft dia. System is powered by two 8600-hp electric motors—both ends of the motor shaft serving as drivers. Entire facility occupies 9375 sq ft.

Paragon-Revolute *introduces a great new concept in reduced size reproduction . . .*

RETRIEVABLE MINIATURIZATION

The Paragon-Revolute Continuous Reducing Printer is the heart of Retrievable Miniaturization. Really a giant movie camera, it takes pictures of drawings while they move through the machine at speeds variable from 3 fpm. to 30 fpm. It takes drawings up to 42" wide, offers reductions of 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8 size. If desired, one of two ratios supplied may be 1:1 for originals up to a maximum of 21" wide by any length. Camera feeds the same as blueprint and whiteprint machines.



Lockheed engineers and Paragon-Revolute representatives compare half-size print with full-size drawing at Lockheed Aircraft Corporation, Missiles and Space Division, Sunnyvale, California. Lockheed officials report that Retrievable Miniaturization has given them the economies and advantages possible from reduced print size without sacrifice of valuable information on engineering drawings.

Andrew T. Johnson, president of the company bearing his name, and son Robert standing in front of their new plant in Burlington, Mass. This graphic reproduction company with three locations in Boston was the first commercial house to install Retrievable Miniaturization. They state: "Retrievable Miniaturization makes real sense to us — and to an increasing number of our customers. Incidentally, our Revolute Processor is doing a fine job in processing direct positive papers.

THE IDEA. Retrievable Miniaturization is a new ingenious method for reducing the size of prints yet keeping them large enough to be completely readable and usable. Developed by Paragon-Revolute, this method is acknowledged as one of the significant advancements in reproduction.

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You owe it to yourself and your company to investigate the advantages and savings offered by this great new concept in reproduction by mailing the coupon below.

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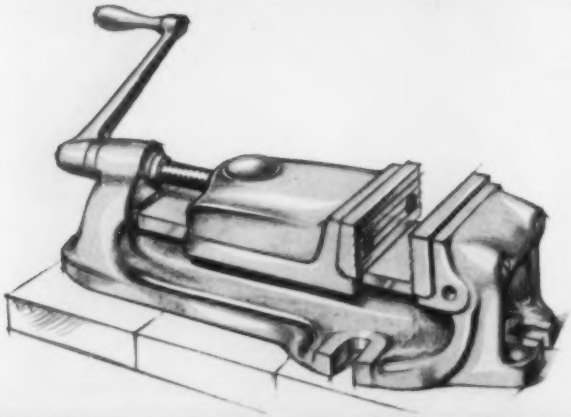
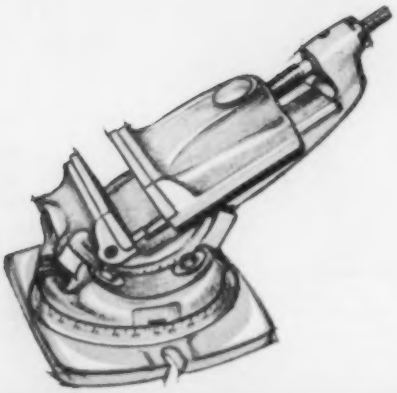
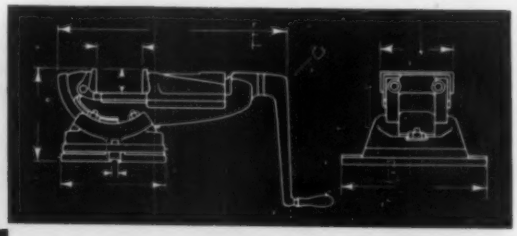
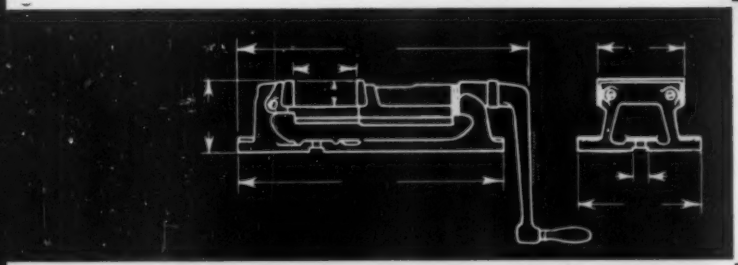
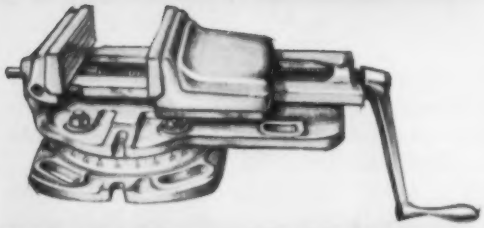
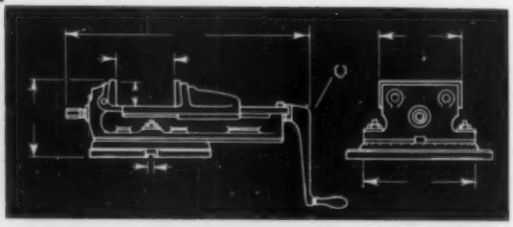




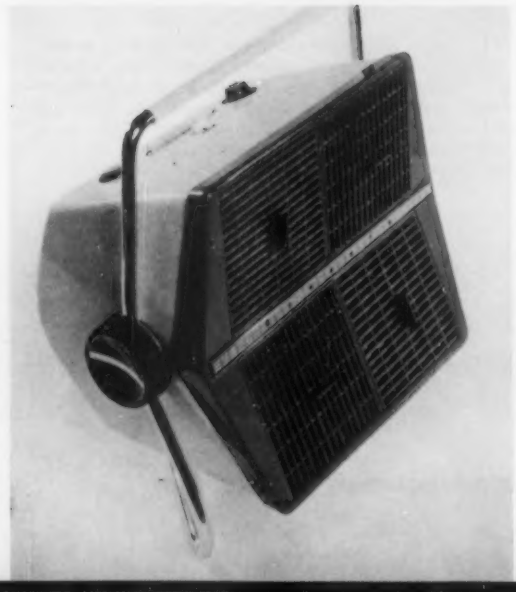








MACHINE VISE from the ZPS Works, Czechoslovakia, was designed with the help of a "creative artist" (Czech for industrial designer, probably) and has jaw opening ranging from about 2½ to 8 in. max, and clamping force of 3100 to 31,000 lb, depending on size. Clamping function is emphasized by low, squat lines, which also ensure min height above machine-tool worktable, and are easiest contours for casting process. Cast-in draining grooves and lip in base channel coolant down onto worktable—not onto floor or operator. Three different models are shown: plain base, swivel, combination swivel and inclinable.



FORCED-CIRCULATION SPACE HEATER, right, has adjustable grilles, directing air in up to four directions at once. Thermostatically controlled fan has two speeds and three heats, all set by pushbuttons and dials grouped at back of steel housing. Housing has been given functionally simple duct shape, but effect is spoiled by chromium tubing, overlarge hub covering and two-tone color scheme. By Goertz Industrial Design Inc, NYC, for Rowenta Metallwarenfabrik, GMBH, Germany.

CLOTHES WASHING AND DRYING center, above, tagged an "advanced concept," is not on the market and may never get there. Dispensers, arranged neatly at the back, have individual actuator-covers lined up to make a functional design element. Control panel is relatively simple in this era of appliances with "space-ship" consoles—but why hang it way up on top, where it will force some housewives to crane their necks? Dryer, with a rotating conveyor belt that lifts, tosses and drops clothes, looks like an interesting departure from standard rotary equipment, but users may be unwilling to give up counter-height clothes-sorting surface provided by all currently available equipment. By designer Ray Sandin, Hotpoint Div, General Electric Co, and consultant Brooks Stevens, Milwaukee.

CANADIAN LETTER BOX, above, of glass-reinforced polyester, is being tested from Vancouver to Nova Scotia. Slot is large enough to accept regulation-size letters and packages, even though top doesn't lift. Box is emptied by unlocking pouch-like lower section, which then drops down to rest against mounting standard. Designed by Finkel-Eveleigh Industrial Design, Montreal; made by Long Sault Woodcraft Ltd.

INCLINED BORING AND TURNING machine, right, has advantages of both vertical and horizontal designs. Enclosure of work area helps to control flying chips and makes them easier to collect for discharge. Machine has three tool heads: one for boring and two side units for circumferential cuts. Uncrowded, easy-to-read control panels are mounted on either side of the sliding panel that hides electrical system. Name hardly needed to be so large. Made by Schiess AG, West Germany.

"In modern manufacturing, electrical control equipment is the very heart of mechanized and automatic operation. Because our plants have become so dependent on this equipment, the cost of 'down time' for any control failure is simply staggering. And, according to many manufacturing engineers, limit switches are the worst offenders, accounting for as much as 70% of all interruptions due to control failures."

Mr. J. S. Wilford, Editor
PRODUCTION Magazine

"At least 60% of the electrical failures causing downtime of the production machinery used in manufacturing home appliances at the Whirlpool Corporation can be traced to faulty limit switch operation. An analysis of the switch failures reveals the inability of limit switches to meet the requirements of high production equipment such as is widely used in our St. Joseph Division."

Mr. C. R. Burg, Maintenance Engineer,
Whirlpool Corporation

"75% of the electrical failures on our machines can be traced directly to limit switch malfunctions. This problem is particularly aggravating to us because we are responsible for the successful operation of our machines and their components on our customer's floor. We have spent a great deal of time engineering protective mounting schemes to compensate for the inability of today's limit switches to check the seepage of corrosive coolants and microscopic grit."

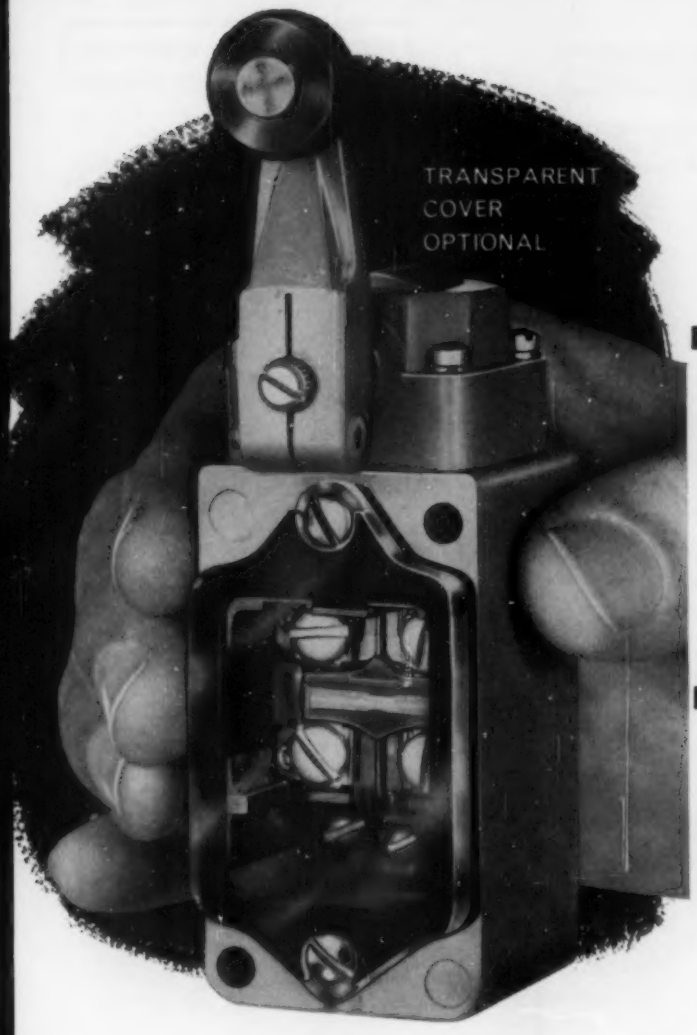
Mr. N. P. Bashor,
Director Electrical Division,
W. F. & John Barnes Company

Production's Enemy #1 MEETS ITS MASTER

Cutler-Hammer announces the *first*

- ***Tolerance Compensated***
- ***Contamination-proof***
- ***Visible Contact***

Extended Life Limit Switch



Tolerance Compensation

The new Cutler-Hammer Extended Life Limit Switch represents a startling break-through in high-precision manufacturing methods. Each sub-assembly is accurately calibrated so that in final assembly all plus and minus tolerances are precision balanced or compensated. Thus, tolerance compensation guarantees every C-H Extended Life Limit Switch will operate identically with precise repeat accuracy and ultra-long life. No binding . . . no sticking . . . no points of concentrated stress or wear.

Contamination-proof

New triple sealing positively checks seepage of all forms of oil, coolants, moisture, and abrasive grit. New cone-seal stops seepage through the operating shaft bearing. New vulcanized bellows-seal between the operating head and body eliminate the troublesome "O-ring" seal . . . won't wear . . . never needs attention. New cover seal seats on a raised lip . . . repeated opening and closing of the cover won't destroy the seal. Total-submersion life tests prove the new C-H Extended Life Limit Switch to be contamination-proof . . . suitable for even dry circuit applications.

Visible Contacts

Another Cutler-Hammer *first* . . . this new Cutler-Hammer Limit Switch provides completely enclosed but *visible* single pole double throw switch contacts. During installation, one glance shows which contacts are open and which are closed . . . no chance for wiring errors. During operations, one glance proves whether the switch is set and operating correctly. Positive visible inspection cuts maintenance costs too.

Compare these features, too!

- **One basic model is readily adapted to all desired forms of lever or plunger actuation . . . for either momentary or maintained contacts . . . for either surface or cavity mounting.**
- **Unsurpassed flexibility: 90° orientation of the operating head. 360° rotation of lever arm with a locking device that holds the adjustment. Lever operators provide clockwise, counter-clockwise, and clockwise-counter-clockwise actuation . . . easy to set on the job without disassembling the switch.**
- **Precise actuation . . . 10° pretravel—40° overtravel or 5° pretravel—45° overtravel.**
- **Visible, saddle-clamp terminals . . . no loose fibre flash-over barriers.**
- **Unitized switch mechanisms are interchangeable . . . speeds replacements when overload or short circuit damage occurs.**
- **Meets all JIC and NMTBA requirements. Easy, complete interchangeability with any widely used limit switch.**

The new Cutler-Hammer Extended Life Limit Switch installs easier, works better, and lasts longer than any of the "oil-tight" limit switches now in use. Exhaustive tests, including total-submersion life tests, confirm this fact! But don't take our word for it. Try it . . . Test it . . . Compare it. The new Cutler-Hammer Extended Life Limit Switch is completely interchangeable with any widely used limit switch. Replace your *most* troublesome limit switch installation with this new tolerance compensated, contamination-proof, visible contact Cutler-Hammer Limit Switch; and it will work better, last longer than any other you have ever used. This is the answer to your limit switch problems.

For descriptive data write for Publication ED143-E249. Cutler-Hammer, Inc., Milwaukee 1, Wisconsin.

CONTROL

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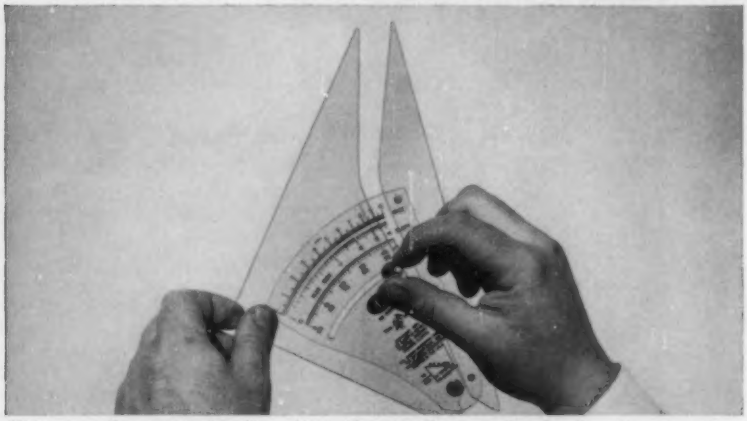

This versatile, easy-to-handle, adjustable triangle is made of yellow-tinted optical-grade acrylic plastic. A clean-cut oval track fitted with metal knurled knob assures ease of operation and lasting tight fit.

New combination protractor-triangle speeds up drafting

Architects, Engineers, Builders, Field Surveyors, Mathematicians—anyone who develops solutions to measurement problems indirectly to determine a wanted measurement graphically or mathematically—will find the Trig-Matk Adjustable Triangle a handy tool. It eliminates much of the graphic work necessary in estimating results or in checking for correct answers.

Versatility with accuracy

Basically the new POST Trig-Matk Adjustable Triangle is a mathematician's tool—accurate to three decimal places.

It combines the functions of a protractor and a triangle into a simple unit, with two fundamental trigonometric relationships of a right triangle. The Trig-Matk provides accuracy within 0.1% in problems dealing with any of the six trigonometric ratios of the sides of a right triangle.

The adjustable protractor has three sets of graduations. One set is graduated in half degrees, labeled *Degrees*, and permits the use of the Trig-Matk as a protractor setting for determining any angle from 0 to 90 degrees.

The second set of graduations, labeled *Slope*, shows directly the *Secant* trigonometric ratio of the angle indicated on the degree scale. The third scale, labeled *Rise*, indicates directly the *Tangent* trigonometric ratio shown on the degree scale.

Examples

This new tool has a host of drafting and engineering applications. Highway designers find the Trig-Matk very useful when making cross sections of roadways at ground level or below. By setting the *Slope* scale to the degree desired, road-curve grades are automatically determined. The protractor can be used to determine the angle of highway ingress and egress lanes.

An indicated angle of 40 degrees on the Trig-Matk (1589) shows directly that the Rise is 8.4 to the base of 10.

Structural Engineers will find the Trig-Matk Adjustable Triangle a simple tool, eliminating the use of both a scale and individual triangles. In addition to the time saved, many of the errors usually associated with the older method are avoided. The Trig-Matk design eliminates the need of frequent reference to handbooks for information on various bevels.

Two Bases

The Trig-Matk No. 1589-12 has a 12" base scale for handy calculation in terms of feet and inches. Number 1589-10 has a metric base scale of 10.

Keep posted on all the latest trends in drafting. Consult your local POST dealer, or write to Frederick Post Co., 3642 North Avondale Ave., Chicago 18, Ill.

POST

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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

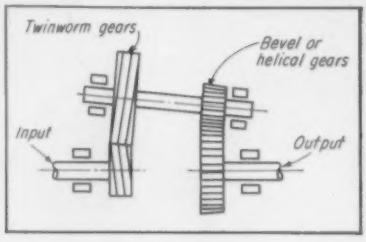
READER TO EDITOR

A Question of Gearing

To the Editor:

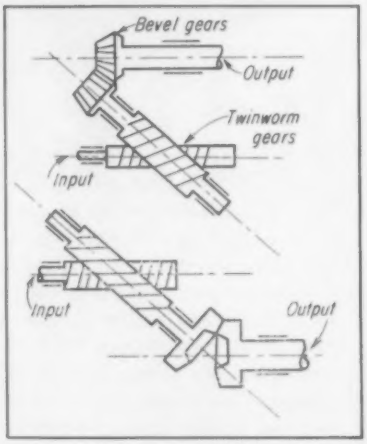
I have read your article "Twinworm—The Self-locking Gear" in the Jan 18 issue, p 41, and found it interesting both as to the subject and as well as presentation.

I would appreciate it if you would clarify one point in your presentation. As I understand, the "self-looking" feature, the Twinworm is dependent upon the "skew" angle between the two axes. You refer to the pairing of the shafts with bevel gears as means for compensating for the angle.



What bothers me is the fact that bevel gears are used to join coplanar axes while "skew" refers to axes not in the same plane. —JOSEPH KAPLAN
Fairchild Camera and Instrument Corp
Syosset, NY

• Mr Kaplan has brought up an interesting point. The published figure (above) appears to show the input Twinworm as having a conical instead of cylindrical pitch surface. Perhaps two clearer methods of coupling a set of bevel gears to a set of Twinworm gears are:



The skew angle is shown greatly exaggerated. Actually it is usually in the order of 2 to 5°. The second sketch employs bevel gears with cone angles supplementary to those in the first sketch. This gives for a compact drive. —NC

When Machines Will Think

To the Editor:

I've noted your comments on creating a machine that can think (Jan 18, p 24) and would like to add a few random thoughts

of my own for consideration. In the first place, "think" is an ambiguous word, loosely attributed to a phenomenon little understood by lay and professional men alike. So far as its basic mechanism is concerned, the giant computers have already mastered the functions of retention, recall, evaluation and selection. Mastery of these functions per se admittedly does not preclude "thinking," as they are simply the tools by which thought is manipulated. However, in the workaday business of living, these functions often masquerade as "thought."

Thought cannot exist until the element of creativity is added. Recalling and stating on command any previously learned fact or process, however complex, does not involve thought. Applying that fact or process through extrapolation of probability, to arrive at a new or unique solution which extends our total vocabulary of skills, does.

The crux of thought then is creativity.

Creativity, simply stated, is the act of bridging from that which is known to that which is yet to be known with the help of two questions: Why? How? The relative success of any extrapolation is directly dependent on individual recall and the astuteness with which these two questions are framed and answered for each specific problem.

From this premise, then, we can conclude that before a machine can "think" it must be able to question—that is, test every new fragment of input information against all retained information, then catalog and file for recall the resulting relationships. It must also have a system of continuous internal programming . . . or curiosity.

Will such a machine ever be built? I believe it's likely. Then what of the elusive, divine, human element? What is left to defy mechanical reproduction?

Ego.

—Arch D. Evans
Highland Park, Mich

COMING EVENTS

MARCH

15-17 . . . . Society of Automotive Engineers, National Automotive Meeting, Sheraton-Cadillac Hotel, Detroit.

29-31 . . . . American Society of Mechanical Engineers, American Power Conference, Hotel Sherman, Chicago.

APRIL

5-14 . . . . International Spring Technical Fair, Utrecht, Netherlands.

4-8 . . . . Nuclear Congress and Exhibit, New York Coliseum, NYC.

5-8 . . . . Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, NYC.

6-8 . . . . Institute of Environmental Sciences, 1960 National Meeting, Biltmore Hotel, Los Angeles.

Typical Control Functions solved by AIR CIRCUITRY

Westinghouse Multi-Position Cylinder

The Westinghouse Air Brake Company's complete line of AIR CIRCUITRY components contains a wide variety of pneumatic positioners to handle almost all of your force and positioning requirements.

No longer is pneumatic positioning limited to a single or double acting cylinder. Remotely controlled by directional and/or pressure control valves, both variable and fixed force and positioning is possible. Along with all the advantages of air, these devices are easily maintained and serviced. Uncomplicated and rugged, pneumatic positioners may be the answer to your control problems.

Typical Applications—The illustrated positioners have been used in almost every field of industry today. These positioners can:

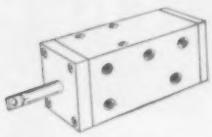
clamp	punch	anvil	convey	push
rotate	lock	form	bend	blank
index	broach	crimp	cushion	pull
hold	squeeze	twist	stretch	eject
feed	shear	raise	brake	move
pierce	lower	press	turn	coin

If you have a positioning problem, let us know about it. It can probably be solved with AIR CIRCUITRY. For more information, ask for our catalog on Positioners.

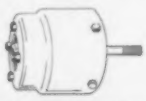
What is AIR CIRCUITRY?

This is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise AIR CIRCUITRY is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will help you boost production and cut costs in your plant or shop.

1. ONE AND TWO STATION POSITIONING—Single and double acting cylinders can perform all types of force and positioning functions. The Westinghouse line of cylinders includes diameters from 1" to 10"; strokes to suit application; single and double end; foot, swivel, flange and trunnion mounts.

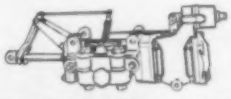


2. MULTI-STATION POSITIONING — Controlled by an associated directional valve, these cylinders attain 3, 4, 5 and 7 fixed positions of stroke. Three position cylinders are available in 2", 3", 4", 5" and 6" diameters. Strokes may be obtained to suit application.



3. VARIABLE FORCE AND POSITIONING — Diaphragm type cylinders are controlled by manually or mechanically operated pressure control valves to achieve a variable force or position of the rod. Various diaphragm areas and strokes available.

4. INFINITE POSITIONING-LIGHT—The actuator positioner has an infinite number of positions, governed by the amount of air pressure acting on its spring opposed diaphragm. Remotely operated pressure control valves dictate the position of the operated lever. This device has a low force rating.



5. INFINITE POSITIONING-HEAVY—The Westinghouse PNEUDYNE® Positioner can position accurately, independent of the opposing force, up to its power capacity. The power capacity is determined by piston size and supply pressure. Remotely controlled by pressure control valves, this device maintains its position throughout changes in the opposing force.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor

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INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

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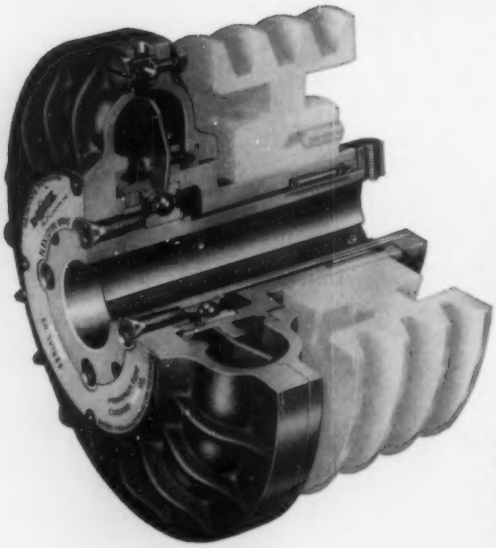
- ☑ Expense of reduced voltage starters?
- ☑ Clutch trouble?
- ☑ Breakage of transmission parts due to instantaneous shock loads?
- ☑ Damage and recurring down-time from overloads?



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THE DRY FLUID DRIVE

It is no longer necessary to accept the destructiveness—the costliness—of conventional starting in the mechanical transmission of power. Flexidyne changes that!

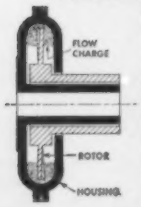
Flexidyne is the new way to start loads *smoothly*—to protect against shock and overload—to save power—all *without any sacrifice of efficiency at full load!*

This revolutionary development is ushering in "the day of the soft start"—which can mean thousands of dollars to you in equipment savings and in better, more economical operation.

Flexidyne is available, off the shelf, in Drives and Couplings. Capacities range from fractional to 1,000 hp. Ask your local Dodge Distributor or write us for technical bulletin.

DODGE MANUFACTURING CORPORATION, 1200 Union St., Mishawaka, Ind.

HOW FLEXIDYNE WORKS



The "dry fluid" in Flexidyne is tiny heat-treated steel shot. A measured amount, called the "flow charge," is contained in the housing, which is keyed to the motor shaft. Inside the housing is a rotor, free to revolve relative to the housing, but connected to the load.

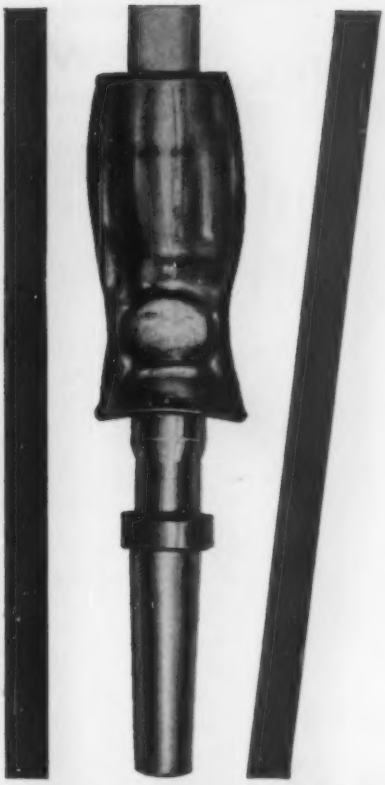
When the motor is started, centrifugal force throws the flow charge to the perimeter of the housing, packing it between the housing and the rotor, which transmits power to the load. Initial slippage is momentary. Housing and rotor become locked together and achieve full load speed without slip and at 100% efficiency.

CALL THE TRANSMISSIONEER — your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

DODGE

of Mishawaka, Ind.

AMP taper technique points the way to greater reliability

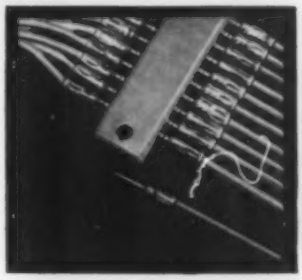


Magnetic Amplifiers, Inc. of New York carefully manufactures its Static Inverters with a step-by-step quality control and testing program to build in the reliability required for aircraft and missile applications.

It found that AMP Taper Technique simplified this procedure. A high speed AMP Automachine pre-terminates circuit leads with crimp-type, pre-insulated solid Taper Pins. Components are then easily tested in the modular stage before final assembly. Crimping eliminates difficult soldering operations and the danger of burning wound components while Taper Technique permits checking and trouble shooting without destroying the main cable. After final assembly, when the Pins are inserted into the Blocks, this Technique provides rugged vibration resistance and operational reliability.

AMP solderless Taper Pins are made in formed and solid types, with or without pre-insulation and mate with a wide range of one or two piece stackable Taper Blocks. You'll find that AMP Taper Technique is ideal for *your* quality control or circuit density problems too.

Magnetic Amplifiers' 250VA Static Inverter Model SIS-425041



AMP Pre-Insulated Taper Pins and stackable Taper Blocks

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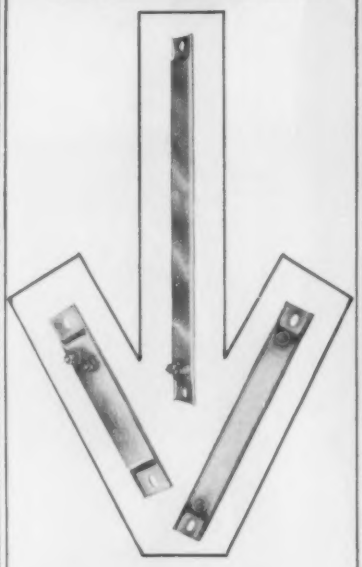

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VULCAN STRIP HEATERS

The surface we mean is *any* flat surface to which Vulcan Strip Heaters can be clamped — dies, platens, molds, etc. Vulcan Strip Heaters are also excellent as air heating sources for ovens, air ducts, dryers, etc. And these versatile heating elements can be formed into circles (one or two-piece) in radius of 5" or more.

Standard one-piece seamless sheaths are made in steel for sheath temperatures to 750°F; Chromalloy to 1200°F. Lengths are from 8" to 42½" (special, shorter or longer). Wattage ratings are from 150 to 1500 (or higher).

Write for catalog and prices.

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VULCAN ELECTRIC COMPANY, Danvers, Mass.

WHY DON'T THEY R&D..?

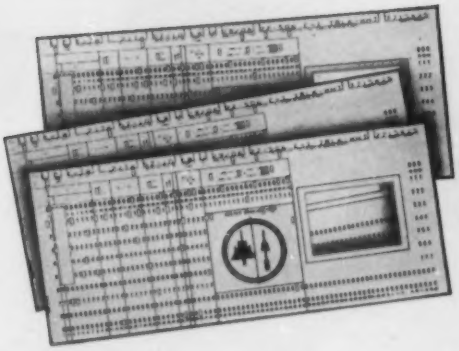
. . . new or better farm machinery. The US Department of Agriculture in its recent Bulletin No. 221, "An Appraisal of Agricultural Research," points to eight much needed improvements:

1. Better use of electric power (only recently supplied to many areas)—particularly labor-saving machinery for production of livestock and poultry.
2. Equipment and methods for mechanizing tobacco harvesting—now performed by manual labor.
3. Tractors and tillage equipment that will prepare the soil better for larger crop yields.
4. Improved equipment for precision planting and fertilizer placement.
5. Better ways to treat crops and apply pesticides for control of weeds, objectional soil organisms, plant insects and diseases.
6. Specialized equipment for developing the potential of new commercial crops.
7. Better methods and equipment to aid storage and handling of farm products, particularly forages and feed grains.
8. New methods for supplying household water and disposing of waste in rural areas.

. . . a fast, inexpensive way to transport packages and small items of freight. A pneumatic tube shuttles mail back and forth under the East River between Manhattan and Brooklyn; why not a similar system for long-distance distribution? Small bundles, properly protected from moisture, could be forced through a pipe hydraulically. With two pipes between points, one for sending and one for receiving, fluid would simply be circulated around a closed loop. Or a single pipe might be more practical when delivery of the fluid itself (water or oil, for example) was also an important advantage. Bundles could be inserted into the line through a wet-lock valve and shunt loop, and delivered to waypoints by switching them into spurs in response to signals generated by a magnetic code on the bundle. —F DEPEW

. . . framed pictures for the home, projected from easily changed 35mm slides—for a change of scene, simply insert a new slide. Image should be projected from behind onto a transluscent ground-glass screen. A unit not over 2 in. thick could be hung on the wall in the usual way or mounted permanently, flush with the wall surface, between wall studs. Projecting the small-frame image onto a large flat surface could probably be accomplished by inexpensive lenses and large curved reflectors of complex shape. Reflecting surface could be vacuum-formed of plastic sheet, coated, and rigidly mounted in the frame. Or perhaps the principle of fiber-optics could be used to conduct light from small segments of the slide to large segments on the screen with bundles of tapered acrylic fibers. —R MYRAM

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.



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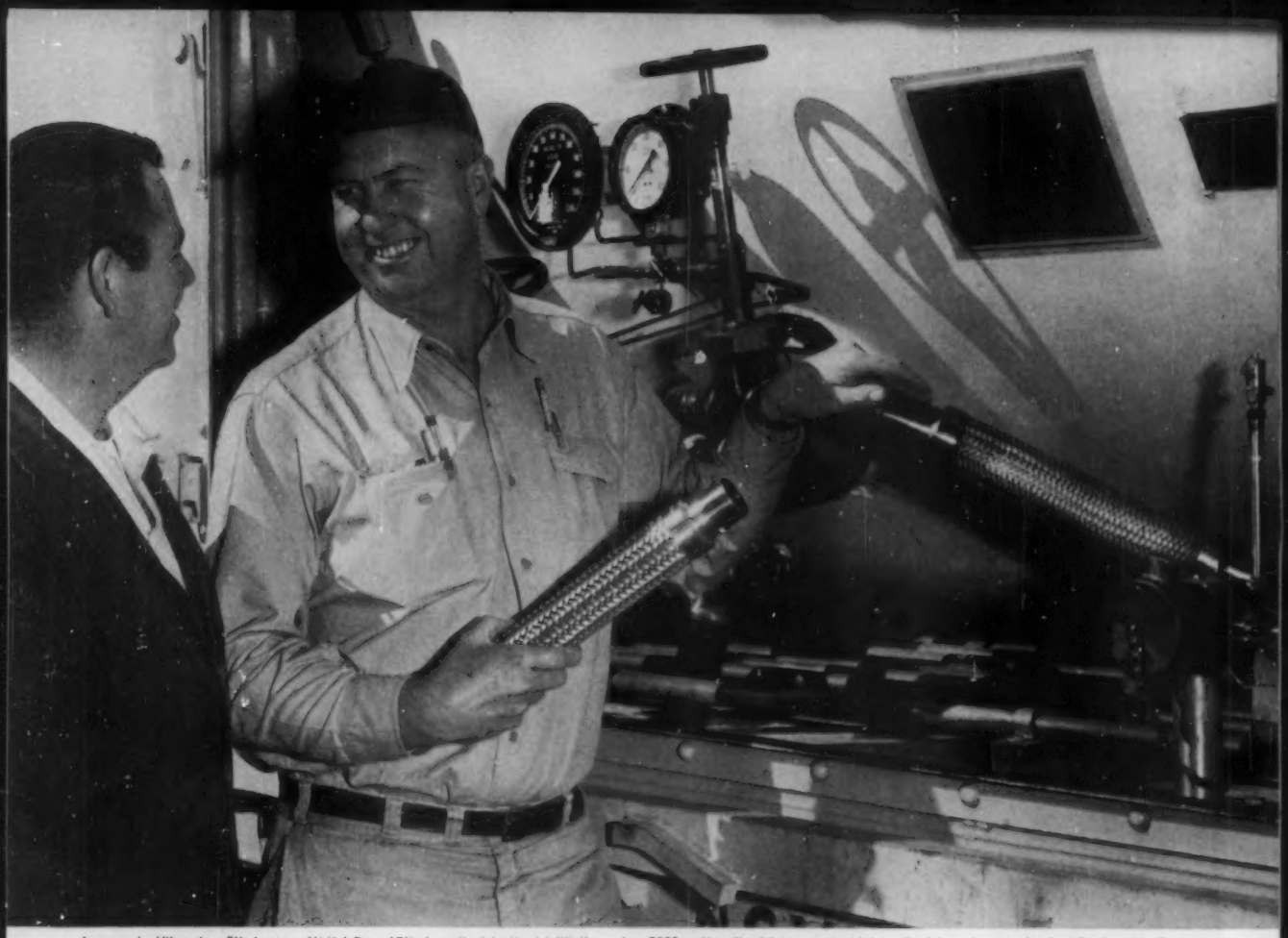


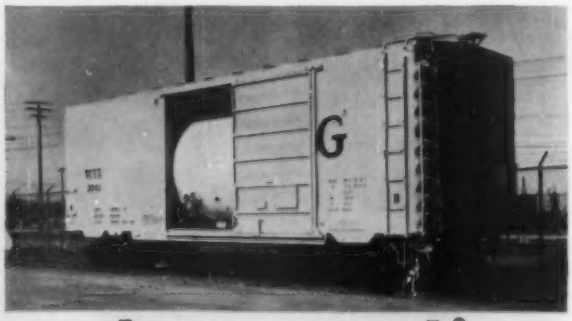
Anaconda Vibration Eliminator, 1½" I.D. x 17", installed in liquid fill line of a 9000-gallon liquid oxygen tank installed in a boxcar by Lox Equipment Co.

When –297°F LOX hits the piping, standard Anaconda tin bronze flexible connectors absorb the shock

Flexible metal hose connections used to absorb thermal contraction and shock in piping carrying liquefied gases vary widely in size, material and design. Anaconda makes assemblies in stainless steel up to 14 inches I.D. for LOX lines in missile ground handling equipment–and other special connectors and hoses in a variety of metals down to ⅛ inch I.D.

But there are many places where standard Anaconda flexible metal hose assemblies of tin bronze can do a job dependably and with economy. Lox Equipment Co., Oakland, Cal., makes unfired pressure vessels to hold liquefied gases. To protect valves and piping from stresses set up when liquid oxygen at –297°F or liquid nitrogen at –320°F begins to flow, the company has found standard Anaconda Vibration Eliminators highly satisfactory. These flexible connectors designed for damping vibration in rigid piping of refrigeration systems have the physical properties needed–the high strength, toughness, and fatigue resistance inherent in tin bronze. In fact, these properties are greater at very low temperatures–tensile and yield strength of copper and copper alloys are materially higher at –300°F than at room temperature. Working pressure of 60 psi is no problem, as standard VE's are designed for applications up to 300 psi–in some sizes up to 500 psi.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are constantly working with design engineers on flexible connectors and hose to meet new problems. They may recommend a standard unit or help in the design of a special unit. For information on standard units or engineering assistance, write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 60122



ANACONDA®
METAL HOSE

PRODUCT ENGINEERING HORIZONS

March 7, 1960

Everybody Wants to be Boss

Most current help-wanted ads for engineers seek *specialists*. Most of the 40% of our current executives who are—or were once—engineers are *generalists*. A recent Booz, Allen & Hamilton survey shows that 38% of 3500 scientists and engineers want a future in administration. Historically, only 8 or 10% will have such an opportunity—if opportunity it is—so most of them will be disappointed. Will the sorrowful ones be the presently so-much-needed specialists or the less-sought generalists?

You guessed it.

A recent *Fortune* survey (Nov, 1959, p 13) of 1700 top executives sheds more light on the subject. It shows that your chances are twice as good for a top job if you went to college (particularly to a "name" school). Engineering or science degrees are favored for top men in oil and gas, utilities, metals-manufacturing, chemicals and transportation equipment fields. Technical men in most industries seem to command the highest salaries. But most of the men surveyed seem to have made their way by dropping their specialty—86% have been in non-specialist jobs most of their working lives.

And regardless of what you may have heard, most of them have stayed put in their companies. Only 13% of the men questioned had been hired from the outside for their present jobs; nearly 70% have been with their present companies 20 years, about 25%, 35 years or more. One out of four in metals manufacturing had worked for three or more other companies, one out of three in appliances and electronics manufacturing, but most of the top men in other industries had made only one switch—or none.

The recent survey of Purdue engineering graduates and an endless number of articles by educators bear out these same elements, provide almost a formula for success. The keys seem to be to develop management inclinations early, to keep on studying in new fields after college to broaden the knowledge base, to find a good company and stick with it.

Herein lies a paradox. Presumably, a man studies engineering to be an engineer, but our social and economic pressures redirect four or more out of ten. We are not unique in this, because in Europe the ratio of engineers to non-engineers in management is even higher. There is considerable sense in it, too, because of the high engineering content of our modern products and the training in analysis and objectivity that engineers receive.

But this brings up another paradox. The devotees of the humanities and the psychologists cry that engineers are devoted to things rather than to people, that they are more concerned with products than with personnel. Yet management is supposed to be —and is—concerned mostly with people. Why so many engineer-managers then?

The answer may lie in a direction these people have not yet looked. Engineers have traditionally been required to devote much more time and effort to the obtaining of a degree than have humanities graduates, so only those with extra capacity get degrees in the first place. What's more, their work requires them to recognize and isolate the human element in decisions. Perhaps this results in men with unique abilities at separating their emotions from their jobs when the need arises.

Industry, meanwhile, has been discovering that a harder-boiled executive attitude must be adopted, that too much lenience has crept into management. So companies may draw still more executives from the engineering side in the years to come—providing the engineers ready themselves for the job.

R. Langeman

With Extras . . . At No Extra Cost

1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
2. NEW "SUPER" CUSHION for air or METALLIC SELF-ALIGNING MASTER CUSHION for oil.
3. HARD CHROME PLATED CYLINDER BORES AND PISTON RODS for greater protection and reduced wear.
4. ONE PIECE PISTON assures better alignment, longer bearing and packing life.
5. FORGED SOLID STEEL HEADS throughout entire line.
6. PILOTED PACKING GLAND with extra long bearing for additional strength and support to piston rod.
7. NO TIE-RODS TO STRETCH—gives you 360° port rotation . . . less space used . . . full strength.
8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

Specify the

T-J Spacemaker

for longer, more efficient cylinder service

You too—can reduce replacement expenditures—lower maintenance costs with the T-J Spacemaker cylinder line. Designed and engineered for ruggedness, and accuracy of operation, the Spacemaker assures longer, uninterrupted operation.

The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

T-J TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

FLEDGELING ENGINEERS VOTE FOR THIS JOB

THEY WANT: *advancement*
experience
challenge

THEY DON'T WANT: *professional meetings*
sick benefits
to publish papers

JOSEPH L SEMINARA, *human-factors specialist, Saratoga, Calif.*

To find what is your most effective "sales pitch" when hiring a graduating engineer, we mailed a survey to senior engineering students at 10 selected colleges across the country. Completed questionnaires were received from 1016 students (60 to 70% response).

The questionnaire asked a student to rank the 17 job characteristics listed in Table I on next page, and his preference for government, educational, or industrial employment. Personal information was requested on grades and specialty.

Breakdown by employment preference:

Industry	83.3%
Government	11.6%
University	2.0%
Other	3.1%

Breakdown by grades:

"A" students	7.7%
"B" students	37.4%
"C" students	54.2%
"D" students	0.7%

According to the survey, the embryo engineer believes that private industry satisfies his top three needs. (1) By far the most important is the opportunity for personal advancement. He is eager to elevate himself rapidly from student to a position of responsibility and recognition. (2) Opportunity to obtain valuable experience and training is next. He is aware that graduation does not mean the end of the learning process, and that his value to his employer increases as he gains experience. (3) The student wants the personal satisfaction of doing important work, and must be challenged by it.

The group as a whole ranked job security fourth—the "A" student rated starting pay and opportunity to continue his education ahead of it. The company with a reputation of successive waves of hiring, then firing, is at a decided disadvantage. The young engineer does not necessarily expect to make a lifetime career of his first job, but he does expect to be permitted to remain on the job as long as he performs satisfactorily.

The four job characteristics of least importance are length of vacations, opportunity to publish papers, sick benefits, and the opportunity to attend professional meetings. The exact order depends on the subgroup. The "A" students and the group preferring government work include prestige as unimportant. Undoubtedly these factors will increase in importance as the students grow older and gain professional experience.

The job-preference subgroups vary their rankings somewhat, but the industry-bound subgroup ratings closely follow the group as a whole. (Logical, because they represent 83.3% of the total.)

Participating Engineering Schools:

UNIVERSITY OF ARIZONA
UNIVERSITY OF FLORIDA
UNIVERSITY OF ILLINOIS
INDIANA TECHNICAL COLLEGE
UNIVERSITY OF MAINE
NORTHEASTERN UNIVERSITY
OREGON STATE COLLEGE
UNIVERSITY OF RHODE ISLAND
STANFORD UNIVERSITY
SYRACUSE UNIVERSITY

Pay Expectations

For the evaluation of the engineering graduate's pay expectations, 500 of the 1016 were analyzed in respect

continued, next page

to the following three questions concerning salary:

1. Indicate the starting salary that you would expect to get in each of the following employment areas at the completion of your academic training:
   .....Government Service .....University .....Private
2. Considering the advantages and disadvantages of working in each employment area, what is the minimum starting salary that you would be willing to work for in each of the designated areas?
3. What salary would you expect to be earning after 10 years' experience in each of the three major job areas?

Tables II and III show salaries expected by the students for the three major work areas. Median salaries, reported by Engineers Joint Council (EJC) in 1958, are listed for comparison. The figures in bold type are salary expectations in student's chosen field.

The salary-evaluation group consists of all the "A" students, all government-bound, and all university-bound students, with the remainder selected at random to make a total of 500.

The group breaks down by grades: "A", 17%; "B", 34%; "C", 49%. By employment preference: Industry, 69%; Government, 27%; University, 4%.

The tables show graduating engineers are realistic in their salary expectations for industrial employment, with "A" students and university-bound students the most optimistic. (The two subgroups are closely correlated because a large portion of "A" students are in the university-bound group.) Each subgroup is most realistic about its chosen job area and underestimates the pay for the other two job areas. All subgroups underestimate university pay, ranking it the lowest, whereas it is actually higher than government starting salaries.

The minimum acceptable pay for each job area indicates students are willing to start in their chosen area for less than the expected amount. Each group feels that industry should pay the most. It is interesting to note that the university-bound student requires a minimum salary of $492 to work for private industry ($61 more than he'd require from a university), yet the actual median salary for private industry is $494. This indicates that you need more than a good starting salary to lure a student of this caliber away from the university.

Monthly pay expectations after 10 years of service are also quite realistic, discounting any inflationary trends. Again, university pay is underestimated by all groups. Students entering their chosen job areas are under no illusion that the low-paying areas will outstrip the others in the long run. In fact, the university-bound student expects to be paid $175 a month less than if he had entered private industry. The true differential is somewhat lower—$58 per month. Government-bound student is very realistic. He expects differential to be $84. It is actually $83.

TABLE I
RANKINGS OF JOB ATTRIBUTES BY DIFFERENT SUBGROUPS

Job-selection Factors	Whole Group	Average Grade "A"	"B"	"C"	Job Preference Govt.	Ind.	Univ.
Advancement	1	1	1	1	1–2	1	2
Experience/Training	2	2	2	2	1–2	2	1
Important, Challenging Work	3	3	3	4	4	3–4	4
Job Security	4	6	4	3	3	3–4	5
Geographical Location	5	7	6	5	7	6	11–17
Continued Education	6	4–5	5	7–8	6	5	3
Congenial Work Atmosphere	7	9–10	8	6	8	8	6–9
Starting Pay	8	4–5	7	7–8	5	7	6–9
Caliber of Colleagues	9	8	10	9	9	10	6–9
Caliber of Supervision	10	9–10	9	10	10	9	6–9
Retirement Benefits	11	11	11	12	11	12	11–17
Opportunity for Travel	12	12–13	12	11	12	11	11–17
Prestige	13	14–17	13	13	14–17	13	10
Length of Vacations	14–15	14–17	14	17	13	17	11–17
Chance to Publish Papers	14–15	12–13	15	15	14–17	14	11–17
Sick Benefits	16	14–17	16	15	14–17	15	11–17
Attend Professional Meetings	17	14–17	17	15	14–17	16	11–17

TABLE II
AVERAGE MONTHLY STARTING SALARIES

	Govt.	Univ.	Industry
Group as whole	$417	$398	$486
"A" students	$435	$411	$530
Students anticipating working in:			
Government	**$435**	$404	$482
University	$453	**$443**	$525
Industry	$410	$394	**$489**
Median in 1958	$446	$467	$494
Min acceptable pay by students anticipating working in:			
Government	**$432**	$426	$466
University	$447	**$431**	$492
Industry	$438	$428	**$461**

TABLE III
AVERAGE MONTHLY SALARIES AFTER 10 YEARS' EXPERIENCE

	Govt.	Univ.	Industry
Group as whole	$702	$639	$814
"A" students	$769	$645	$876
Students anticipating working in:			
Govt.	**$714**	$632	$800
Univ.	$741	**$683**	$858
Industry	$686	$640	**$816**
Median in 1958	$694	$719	$777

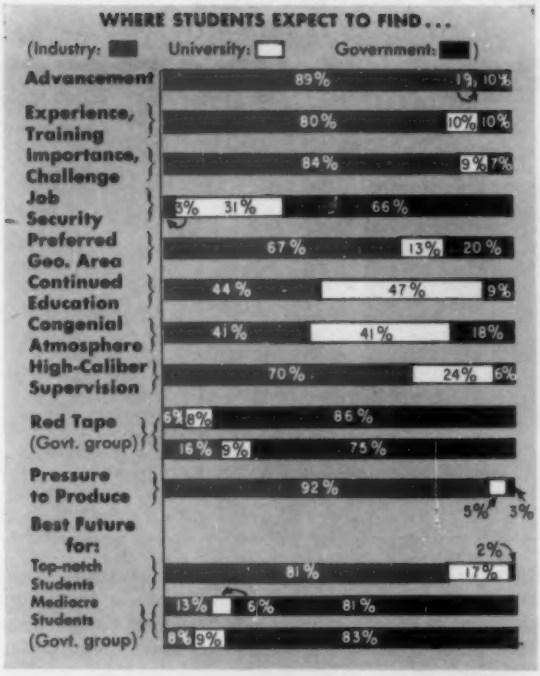


TABLE IV

RATINGS OF OTHER JOB FACTORS

	Govt.	Univ.	Industry
In which of the following employment areas would you most likely find a job with the best retirement plan?	70%	2%	28%
Where would you expect to be associated with the highest caliber of working associates?	4%	58%	38%
In which of the following would you expect to obtain a job with the most liberal vacation?	45%	40%	15%
Where you expect to find the most liberal sick-leave benefits?	68%	7%	25%
Which type of employment offers the most encouragement to publish technical papers?	7%	74%	19%
Where would you most likely get a job in which attendance at professional meetings or conventions is encouraged on "company" time?	12%	39%	49%
In the eyes of the community, a job in the following area carries the most prestige?	8%	59%	33%
Which of the designated employment areas would involve the greatest amount of travel in connection with the job?	49%	2%	49%
What general impression have you received from the faculty of your school concerning the best employment area to enter?	3%	9%	88%

Job Areas Compared

The bar graph shows how each major job area rates with regard to the important job factors. The responses of the entire 1016 students are used. For "Red Tape" and "Best Future for Mediocre," the responses of the government subgroup are included as a comparison. These students agree with the whole group as to where the most red tape will be found in connection with applying for, and securing a job. They also agree with the group as a whole as to where the mediocre student will most likely get by. About one out of three students preferring government service has an "A" or "B" average. Four out of five students expecting to work in a university are in the "A" or "B" category. Of those headed for private industry, about half have an average of "A" or "B."

Remainder of the job factors are considered relatively unimportant by the seniors. Table IV sets forth these questions and gives the percentages by job areas. The last question, dealing with impressions received from the school faculty, indicates that of the students who received an impression (90% of the 1016 seniors), 88% were encouraged to enter private industry.

What Private Industry Offers

The engineering graduates feel private industry offers them: advancement, experience and training, important and interesting work, a preference for geographical location, encouragement for continued education, and a congenial work atmosphere with high-caliber supervision.

Of the high-ranking factors, job security is where private industry may be at a disadvantage. The students expect to find security in government or university work—but not in private industry, especially in the event of a severe depression.

One factor, which was not ranked, is that of pressure to produce. This yielded the most one-sided response of the survey, with 92% of the students attributing pressure to private industry. Some students may prefer the other two job areas for this reason.

Because 81% of the students think that top-notch students have the best prospects in private industry, and 81% think that "engineers of only modest talents would most likely get by" in government service, how many "C" students (who might make excellent engineers regardless of their scholastic average) head for the government because of this preconditioning?

EDITOR'S NOTE: For articles on recruitment and salaries of engineers, see:

Engineer Recruitment, Nov 2 '59, p 28, discusses recruitment of experienced engineers and refutes reports of widespread pirating, auction-block bidding, and luxurious entertainment. The predicted 10% who will change jobs in 1960 will do so for a better working atmosphere and a more challenging assignment.

Engineer Salaries Up 13% Since '56, Jan 5 '59, p 26, a report of median earnings of engineering graduates, covering 1958, released by Engineers Joint Council.

Money, Glamor, Challenge Decide Today's Engineer Student on Future, Sep 15 '58, p 37. Spokesmen from various engineering schools tell what they think attracts students.

when design calls for a choice:

VIBRATORS—4 TYPES

Vibrations in equipment aren't always undesirable — many applications, from degreasing a watch to shaking a large hopper, require a vibrator of some sort. Here are the main types, including a look at designs worked out by the author.

FREDERICK MARICH, *assistant editor*

vibration force of a few grams is sufficient to keep a servovalve from sticking. On the other hand, you need 1½ tons of force to operate a vibrating drill that breaks up rock. But the difference is not only in the size of the device and amount of power needed. The source of available power and flexibility in varying the power and frequency are factors in choosing the right type of vibrator.

For purposes of design, vibrators are grouped in these general types:

1. Electric—pulsating magnet or motor eccentric—with variable force, but frequencies limited by electric current used.
2. Hydraulic or air—pulsating or rotary types—with wide range of both force and frequency.
3. Mechanical—with limited range of force and frequency, but wide variation within the range.
4. Air cylinder—a new development in the field of vibrators and highly efficient for custom-designed applications.

All these types have one common function, which is to impart vibratory motion to a mechanism or material. It is the application that furnishes your guideline to which type shall be used. For example, a lightweight electrical unit is the practical answer when you want to keep a servovalve from sticking, or drive a feeder on a packaging machine. For the servovalve application a gentle moderate-frequency force oscillates the valve gate into position directioned by the servomotor. Similarly, an ultrasonic vibrator operated at ultrahigh frequency but with moderate, or even imperceptible force, shakes dirt and grease out of watches and other small mechanisms. At the other extreme, you need large units to operate cutting tools or vibrate large hoppers.

How Much Power?

The force that a vibrator exerts depends upon the power input and a number of other factors. Their relationship is not easily solved mathematically. It is easier to correlate them by experimental methods. For example, in the application of vibrators to big hoppers the major factors are: thickness of hopper plate, size and shape of hopper, structural reinforcements, material in the hopper and its condition—dry or wet. Most important is thickness of plate. The following data give its relationship to power required to move various types of material weighing 100 lb/cu ft.

Power, watts	Hopper-plate Thickness, in.	Hopper Capacity, cu ft
15	0.025–0.032	1
45	0.032–0.062	2
75	1/16–1/8	7
150	1/8–3/16	20
275	3/16–1/4	50

One fixed rule—if it can be called that—is this: To reduce cost and simplify control, use the lowest power and frequency actually needed. Also, vibration must be so controlled that it is confined to the work it is supposed to do. This will keep the vibration waves from cancelling each other and prevent undue stresses on the critical parts of the machine. But there are exceptions. The magnetic type should be slightly oversized to prolong life of the unit. Characteristic advantages and limitations of various types are given in the accompanying table.

Electric Vibrators

These are simple to operate and economical for certain intermittent applications that are not particularly severe. Electric power is used directly, which boosts efficiency. This is true of both the pulsating magnetic and the motor-eccentric types. In the first, a pulsating magnet with mechanical springs for recoil produces either 3600 or 7200 vibrations per minute (vpm).

All such magnetic vibrators can be equipped with a rectifier and controller where variable power output is required. Where variable power is not required, highest efficiency can be obtained at nearly full power, because limiting the

VIBRATORS—AND THEIR APPLICATIONS

	ELECTRIC		HYDRAULIC OR AIR		MECHANICAL	AIR CYLINDER
	Pulsating Magnetic	Motor Eccentric	Pulsating	Rotary		
Frequency, vibr./min.	3600; 7200	900–10,000	300–2400	1200–80,000	9–1800	30–500
Power (hp or psi)	1/40 to 4 hp	1/2 to 2 hp	40 to 90 psi	10 to 120 psi	1/20 to 1 hp	40 to 80 psi
Components	Magnetic unit Rectifier Controller	Motor unit Switch box	Pulsator Valve Pressure unit	Rotary unit Valve Pressure unit	Eccentric cam unit Motor-reducer Switch box	Air cylinder Valve Pressure unit
Service	Packing mach. Feeders Hoppers Cutting tools	Packing mach. Shakers Hoppers Compactors	Packing machines Feeders Hoppers Compactors		Conveyors Feeders Hoppers Special applications	Packing machines Hoppers Special applic.
Maintenance	Low for intermittent operations, high for continuous operations		Possibility of air & oil leakage requires much attention		Low frequencies allow for greater life; requires routine lubrication	Air leakage is much less in this type
Advantages	Most efficient for intermittent operations; wide range of standard units available		Flexibility in output range does not require precise sizing of units; suitable for explosive atmospheres		Special designs can furnish any output range; low frequencies allow continuous operation	Most efficient for custom jobs requiring 24 hr/day operation
Limitations	Frequency modulation range limited, and any lowering of power lowers the efficiency; limited life		Noisy on pulsating units; rotary units require relatively more power		Custom-designed units have high first cost	Custom-designed units have moderately high first cost

power with a controller cuts the amplitude without cutting the frequency. This indicates that a smaller unit might be preferable for a particular operation. If a wide range of operating power is actually needed, consider possibility of an air or hydraulic type. Remember, too, that the life cycle of any high-frequency vibrating system using mechanical springs will likely be limited by the number of deflections the springs can endure. If the operation is continuous, life cycle will be short. Nevertheless, magnetic type is widely used in packaging machinery, hoppers, cutting devices, testing machines, conveyors and feeders.

The motor-eccentric type is an unbalanced motor that gives one vibration per revolution. Like any motor, it operates at the rated speed, 900, 1200, 1800 or 3600 rpm —same figure as the vpm. Specially designed units, like the repulsion-induction motor, can give 7200 vpm. Another special is the so-called universal motor designed for 9000-10,000 vpm. Motor-eccentric vibrators are particularly handy in portable machinery for short intermittent operation, but their life is limited to about several thousand hours. Some units, made of heavy-duty materials, have a longer life.

In general, electric vibrators are recommended for intermittent operations up to about 8 hours/day. Greater usage will result in high maintenance and replacement costs.

Hydraulic or Air Vibrators

Most of these vibrators will work off either hydraulic or air pressure. Such pressure can be a central supply, or generated especially for a particular installation. These vibrators generally have a lower first cost if an economical source of pressure is available.

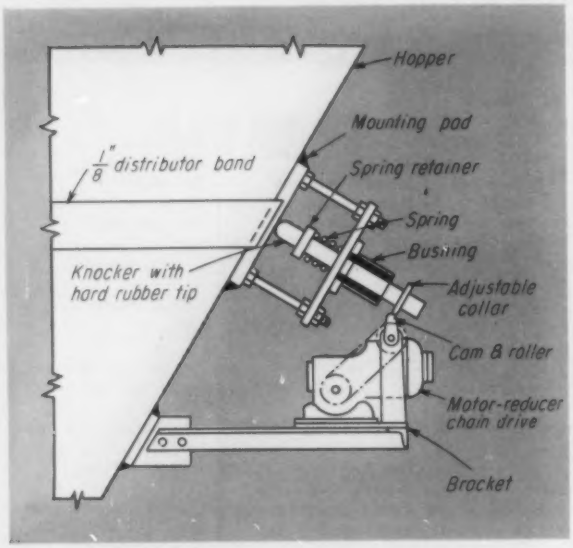
Two distinct types are available—pulsating and rotary-ball types. The pulsator is more efficient—it produces a vibrating force by abrupt pulsation of the pressure. The other type is much quieter but, because of its rotating ball, requires more energy to produce the centrifugal forces. Both types are less efficient than the electric types: They take electric energy, convert it to pressure and then to mechanical motion. But they are advantageous in applications with explosive atmospheres where electric types would be hazardous. Also, a wide range of standard units are available, and the range of individual units can be varied by merely throttling the pressure. A change in operating pressure will change both the frequency and the force. This minimizes necessity to size the units precisely according to output requirements.

Mechanical Vibrators

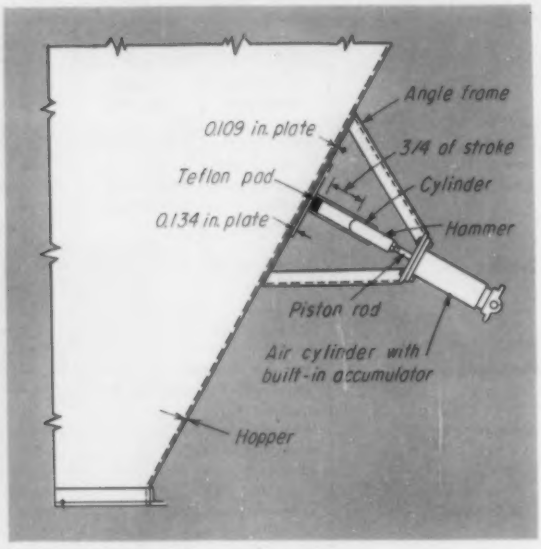
This category, too, covers two general types—eccentric cam and harmonic spring. The first is used for the same applications as the motor-eccentric type. The eccentricity that produces vibration in the cam type is housed separately and connected to an ordinary motor by means of a flexible coupling, belt or chain drive. It has a longer life than the motor-eccentric, and offers greater range of output.

The harmonic-spring type uses a standard electric motor and drive mechanism coupled to mechanical springs to create a harmonic vibration. This type is particularly efficient in long, vibrating conveyors where minimum power consumption is needed to make them more competitive with other conveyor types. Ordinarily, vibrating conveyors must incorporate auxiliary processing functions, such as heating, drying or cooling, to justify their increased operating costs.

A special version of the eccentric-cam type is the mechanical knocker (sketch on next page). It was developed by author to fulfill a special application for which neither electric nor air vibrator would do. It simulates manual hammer blows at low frequency for continuous operation 24 hours per day. Maintenance and repairs are made at long intervals that coincide with plant shutdown.



MECHANICAL KNOCKER, custom designed, gives high amplitude and low-frequency vibrations.



AIR-CYLINDER VIBRATOR has independent controls for impact load and frequency; operates 24 hours per day.

The unit consists of a motor-reducer with chain drive, cam and roller which actuate a spring-return piston that has a hard rubber tip. The spring can be changed quite readily to increase or decrease intensity of the hammer blow. Speed of the motor-reducer unit can also be made variable to change the frequency. Consequently, flexibility is much greater than can be had with electric or air vibrators. The first cost, however, is also greater. Maintenance is reasonably trouble-free if heavy-duty components are used and wearing surfaces of roller and collar are hardened. Custom-designed units like this one are particularly advantageous in machines that operate continuously with little or no attention.

Air-cylinder Vibrators

For machines that require continuous vibration 24 hours per day, throughout the year, power consumption is very important. The new-type air-cylinder vibrator sketched in this page is the logical development for such applications. With a heavy-duty, standard commercial air cylinder it requires less maintenance than any other vibrator for the same job. It also uses less air because frequency is controlled independently of the air supply by means of an electric timer. An air valve governs intensity of each stroke, so the vibrator uses only the power actually needed. Additional adjustment of stroke intensity can be made with the lock screw on the piston rod. Generally, the piston travels ¾ of the stroke before striking the surface to be vibrated. With independent control of both force and frequency, this unit offers ideal flexibility. The first cost compares favorably with that of a comparable mechanical unit; operating cost is less than for other air vibrators.

Suggestions for Mounting

Application of pulsating magnetic or high-frequency hydraulic vibrators to hoppers and packing machines requires special care to make sure that vibration is confined to the purpose intended. Otherwise, unnecessary strain will be placed on other critical parts of the machine. For example, proper mounting techniques on hoppers is essential. Illustrated on next page is faulty design of a mounting for an oversize electric vibrator on the hopper of a spray dryer that has both inner and outer cones. Here, both cones of light-gage metal are put under excessive strain by the bulky mounting of the vibrator. This will cause fatigue cracks to develop and the heavy vibrator will, in time, crash to the floor.

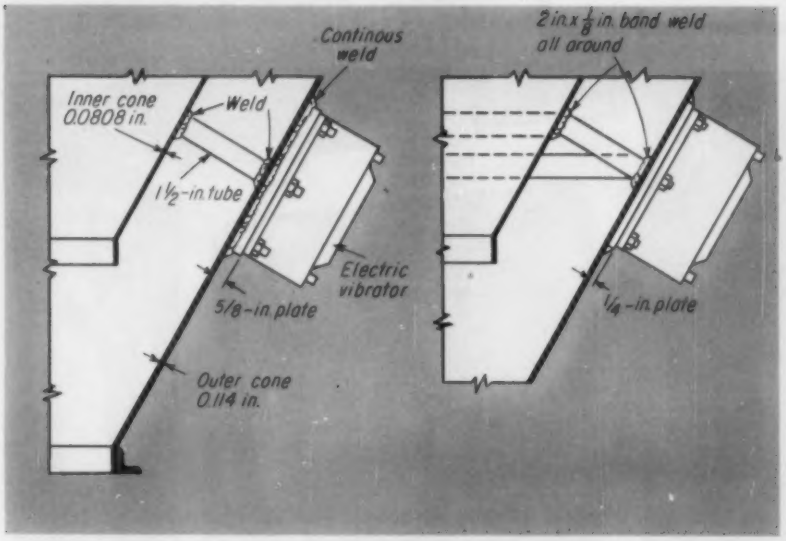
A remedy is shown in the right-hand portion of the sketch. The inner cone is reinforced by a tack-welded vibration-distribution band. The outer cone is reinforced similarly and a ¼-in. mounting plate replaces the ⅜-in. plate. Further improvement can be obtained by using two smaller vibrators spaced 8 to 10 feet apart on the circumference. However, decreasing the size of a magnetic vibrator for this application will lower its life cycle. So this should not be done unless lower life cycle is justified.

Static Grounding

Also important for high-frequency vibration of packing machines and hoppers is the elimination of static electricity. The vibratory motion attracts positively charged particles in the hopper to the negatively charged hopper and packs them down tighter as they accumulate. Since most of the products in a spray dryer are hygroscopic, their absorption of moisture from the steam-laden air causes a heavy crust to form on the inside of the hopper. This cancels the action of the vibrator.

It is quite simple, however, to eliminate static. Ground the hopper with strands of copper wire soldered at not more than 3-ft intervals on the circumference of the hopper, and then grounded to the nearest steel girder. It is not sufficient that such hoppers are already grounded at

THREE DESIGNS BY THE AUTHOR

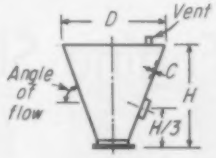


ELECTRICAL VIBRATORS require special mounting. Design, far left, will crack thin bin walls. Correct mounting is shown at right.

VIBRATOR SIZE FOR HOPPERS

Hopper Size			ELECTRIC		HYDRAULIC OR AIR		MECHANICAL		AIR CYLINDER		
D, ft	H, ft	C, in.	Watts	Vpm	Cfm @ 80 psi	Vpm	Hp	Vpm	Dia, in.	Stroke, in.	Vpm
1	1	1/32	15	7200	1/2	7000	1/40	9–20	1	2	75–500
2	1–1/4	1/32	25	7200	1	7000	1/40	9–20	1	2	75–500
3	2–1/3	1/16	45	3600	1–1/2	5300	1/20	15–20	1–1/2	3	5–75
4	3	1/8	75	3600	2	4900	1/12	15–30	1–1/2	3	5–75
5	3–3/4	3/16	150	3600	2–1/2	4700	1/4	25–50	2	4	5–75
6	4–3/4	1/4	275	3600	3	4000	1/2	30–60	2	4	5–75

Product Flow, cu ft/min.	Vent-pipe Size, in.	Product	Angle of Flow, deg
0.1	½	Alumina	22
0.4	1	Ashes, dry	40
1.0	1½	Carbon	21
1.8	2	Sand	34
4.0	3	Zinc powder	54



their supports—static electricity must be grounded as near its source as possible.

The tables above give vibrator sizes for various hoppers, and auxiliary information on vent sizes and angles of flow for different materials. They are for conical hoppers. For rectangular hoppers it is recommended that two vibrators on opposite slopes be used; their size should be slightly smaller than the single vibrator for the corresponding conical hopper. For larger hoppers than shown, vibrators should be set approximately 8 feet apart on the circumference.

To insure that action of vibrators will not be cancelled by hopper-design factors, it is important to check vent size and hopper slope angles. This auxiliary information is also tabulated below. Angle of the hopper slope should at least equal angle of flow for products shaken in the hopper. In rectangular hoppers the valley angle at the corners should correspond to this angle.

For REPRINT of above article, just check P37 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: For another article on vibrator application see:

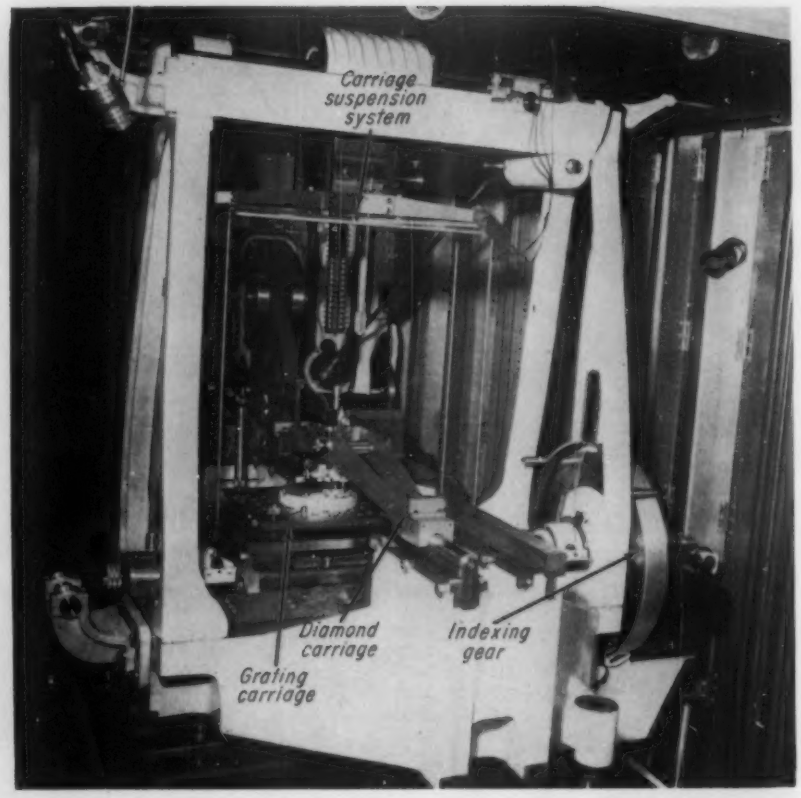
Hydraulic Vibrators, Dec 9, '57, p 94. Gives details of new concept in product testing for vibration fatigue with hydraulic vibrators. Includes diagrams of typical test system.

For isolation of undesirable vibrations see:

Vibration Isolators with Zero Stiffness, Sep 29, '58, p 52. Details, with brief description of principles involved, of 7 vibration isolators using coil springs.

For calculation of critical vibration frequencies see:

Critical Frequency in Stepped Shafts, Jan 11, '60, p 57. Derived equations give critical speed and frequency for uniform round shafts; round, tubular and rectangular stepped shafts.



Machine produces diffraction gratings by ruling up to 50,000 lines per inch on glass. Why the precious stones for bearing surfaces? They provide maximum smoothness and hardness plus excellent resistance to temperature variations.

Ruling Engine Slides on Sapphires

BACKBONE OF THE ENGINE is a pair of nickel semisteel castings. Front casting supports the ruling mechanism; rear casting carries the driving mechanism. Each casting is mounted on separate pier by means of its 3-point suspension system.

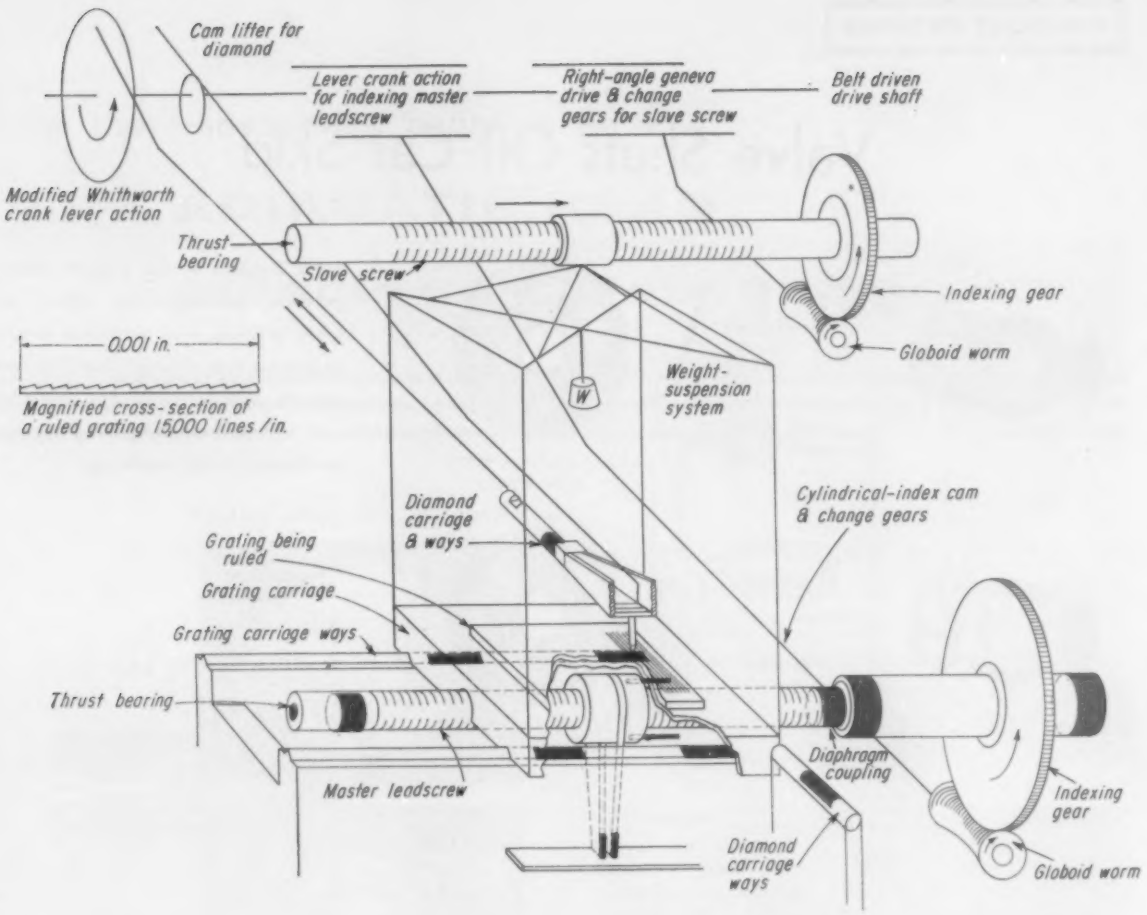
Two leadscrews are incorporated. The slave screw, mounted 3 ft above the work surface on bronze bearings, carries weight of the grating carriage and grating blank through a counterweighted suspension system. The master leadscrew, on sapphire bearings, positions the grating carriage by means of a split nut and is isolated from the mechanism used to index it. The split-nut assembly that moves the grating carriage is prevented from rotating by two fins with cylindrical sapphire pads. These pads slide along a straightedge 9 in. below the screw. Thrust of the split nut is transmitted by two ball-end pushrods fitting conical holes in the nut and equalizing collar of the grating carriage.

The dividing mechanism, used to rotate the master leadscrew, consists of a globoid worm and indexing gear. The drive worm engages 72 teeth of the gear, providing a good averaging effect. Indexing gear is mounted on a hardened nitralloy shaft running in sapphire bearings; worm is mounted in a zero lead bearing in the semisteel casting. Polished and lapped bearings are lubricated with molybdenum disulfide and oil to achieve a low starting torque. Coupling between leadscrew and dividing gear is a tubular extension with a steel diaphragm at each end. The diaphragms allow leadscrew to bear only on its own thrust bearing and not be affected by the indexing gear.

The diamond used to rule gratings is mounted in the diamond carriage that bridges the gap between two round ways. The carriage passes over the grating carriage and carries the adjustable diamond-holder. The bearing surfaces that run on these ways are sapphire slabs (4⅛ x ½ x 3/16 in.) cemented to cast iron pads fitted to each end of the diamond carriage.

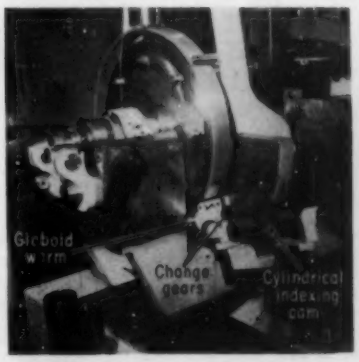
The grating carriage is made from a nickel semisteel casting and has eight 4 x ½ in. sapphire bearing pads recessed in its bottom. The ways on which it rides are high-chrome, high-carbon tool steel fitted into slots in the main casting. The compound levers used in the suspension system ensure that irrespective of the position

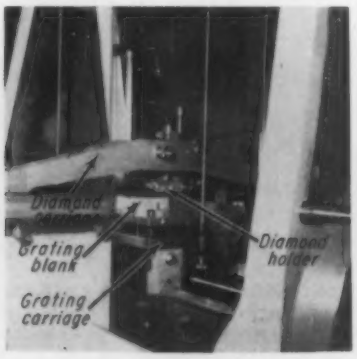
PS . . . Completed after 15 years of research and construction, the ruling engine is housed in a windowless, dust-free, insulated building with stone walls 12 in. thick. The machine is mounted on piers isolated from the building and external vibration by layers of sand and vibration-absorbing cork. Developed and produced for the Office of Naval Research by Edward Liebhardt, Diffraction Products Inc, Maywood, Ill.



of the grating blank on the carriage the bearing pads will always carry an equal share of the load. Load on the pads can be diminished up to the point where the carriage will actually float.

DRIVING-INDEXING MECHANISM of the ruling engine is powered by a 1/5-hp dc motor whose speed is checked by an induction generator coupled to it. Motor rpm is controlled by a circuit which uses the 720-cycle ac generator output as a standard. Motor speed of 1200 rpm is reduced by compound friction wheel drive and endless, flat canvas belt. Final speed of 16 ruling strokes per minute is transmitted to the diamond carriage from the driveshaft by a modified Whitworth crank lever action. This provides uniform rectilinear surface speed of the diamond over the entire length of the ruling stroke. Stroke of diamond carriage is constant to prolong the life of the carriage ways. Line length is varied by raising or lowering the diamond as required during the ruling stroke.

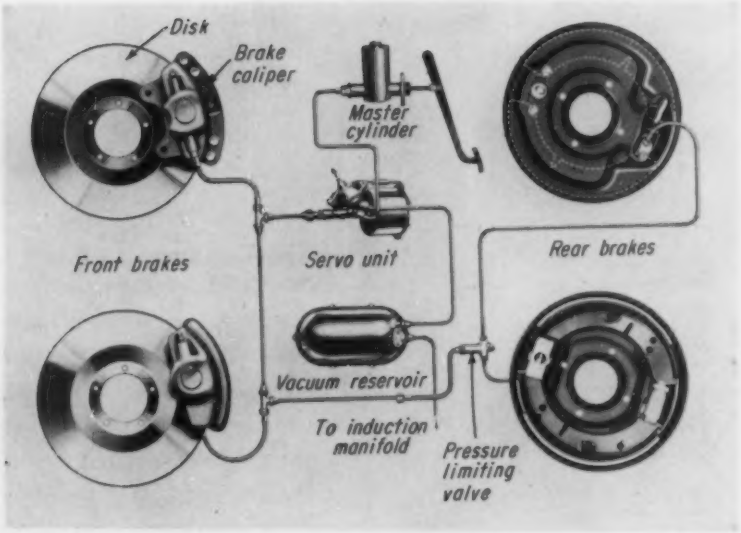


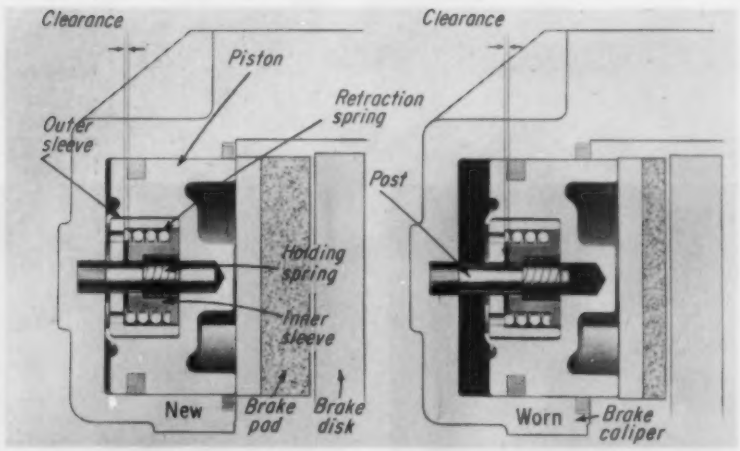


A crank on the driveshaft provides a reciprocating motion once each revolution (or each stroke) to a tapered pin running in a helical groove generated in a cylindrical indexing cam. This cam is connected through change gears to the globoid worm that mates with the master dividing gear. A right-angle Geneva mechanism and change gears drive the slave screw. The indexing cam accelerates the indexing gear and grating carriage slowly for the first ¼ of the motion, holds speed constant for ½ the carriage motion and then slowly decelerates the carriage to rest. At the end of travel, the tapered pin is retracted and returned to initial position.

Valve Shuts Off Car Skid

New English brake system incorporates self-adjusting disks on front wheels and anti-skid mechanism on rear drums. Combination system compensates for unequal adhesion produced by weight transfer during hard breaking.

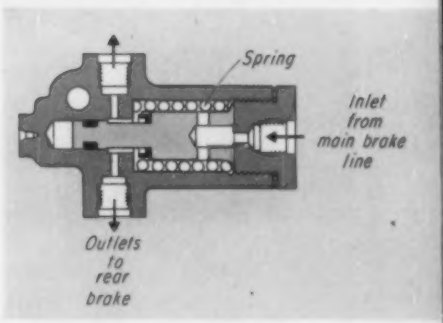




SELF-ADJUSTING DISK BRAKES . . . provide progressive adjustment, with constant clearance between brake pad and disk. Piston retraction is governed by preset clearance between the inner and outer sleeves. Hydraulic pressure behind the piston moves the piston and brake pad into contact with the wheel disk and reduces clearance between sleeves to zero. Retraction of the piston and brake pad is effected by expansion of the retraction spring between the sleeves. This restores the preset clearance.

Inner sleeve slides on the post attached to the caliper housing, but is restricted by the holding spring—mounted with an interference fit on the post. Outer sleeve is crimped into the piston; retains inner sleeve and retraction spring.

When brake pad wears, hydraulic pressure reduces clearance between sleeves to zero. This pushes the interference-fit holding-spring along the post until full load contact between the friction pad and disk is established. When brake pressure is released, the retraction spring again withdraws the piston. This restores the preset clearance between sleeves.



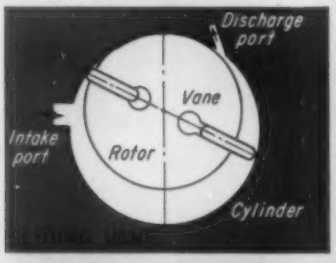
SPRING-LOADED VALVE . . . restricts hydraulic pressure in the rear-wheel brakes to a preset maximum while pressure in front-wheel brakes is rising. Valve closes when its spring is overcome by the selected pressure in rear-wheel circuit. The anti-skid valve then remains closed until main-line pressure drops below designed maximum pressure for the rear wheels. Optimum pressure is determined by the maximum braking torque capacity of the rear wheels after weight transfer occurs.

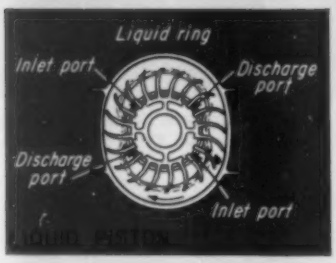
PS . . . Disk brakes on front wheels are required to prevent brake-fade during hard stops. Drum brakes on rear wheels are sufficient to handle reduced brake loading resulting from weight transfer during stops. Combination system with anti-skid device and vacuum servo is produced by Lockheed Hydraulic Brake Co Ltd, Leamington Spa, Eng.

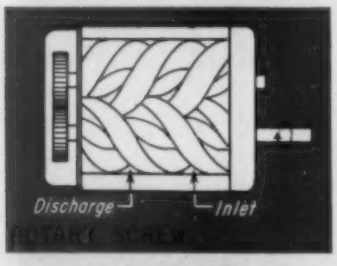
from thermodynamics, equation for . . .

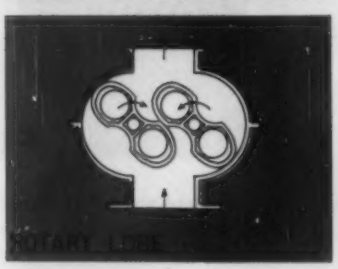
ADIABATIC HEAD selects compressor type

ROTARY POSITIVE-DISPLACEMENT COMPRESSORS









If you know the pressure ratio, required flow and shaft speed, the "adiabatic head" concept can lead directly to the choice between a positive-displacement and centrifugal compressor—for all gases. Here's a step-by-step method, including the needed reference data.

WILBUR A SPRAKER, and
ROBERT A STEIN
Aeronautics and Thermodynamics Div
Battelle Memorial Institute, Columbus, Ohio

The word "compressor" is loosely defined in practice. For many years, "blower" meant any machine that compressed gas with a pressure rise from 1 to 35 psi; a "compressor" produced a pressure rise greater than 35 psi. This definition ignored a number of single-stage centrifugal and axial machines, and today the distinction between blower and compressor has vanished; compressor now means any machine producing a pressure rise greater than 1 psi. Under 1 psi it is a fan.

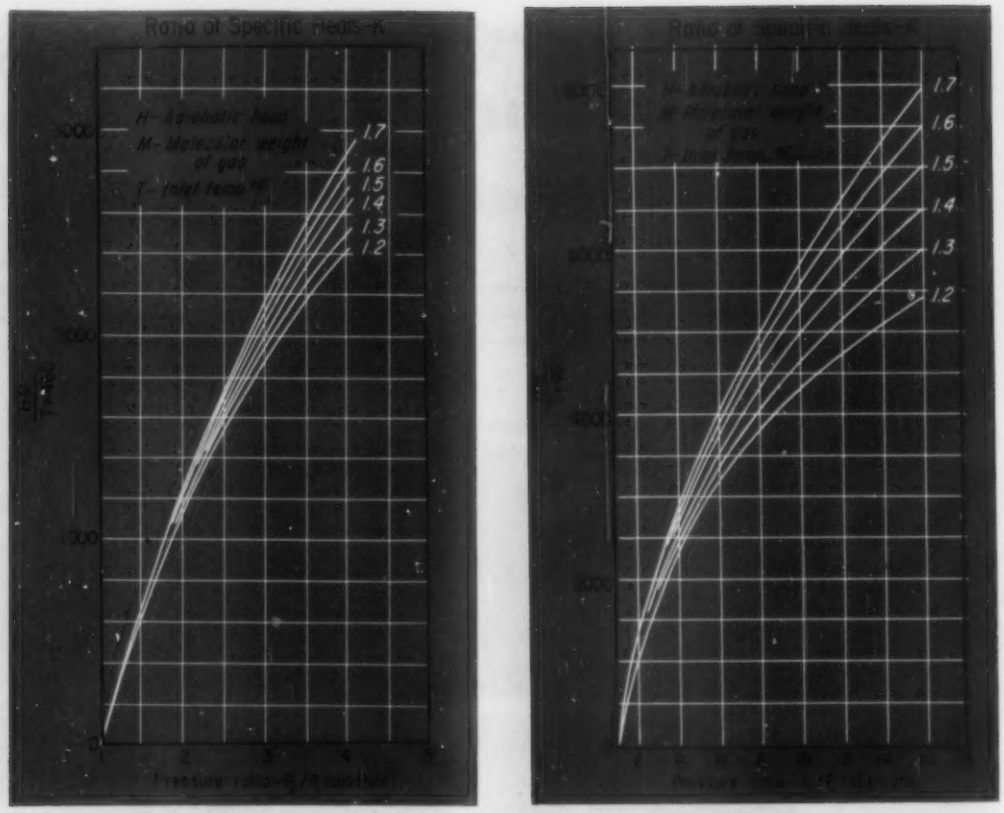
A "small" compressor for our discussion here has a flow of less than 1000 cfm. While this is an arbitrary dividing point, the selection problems change character at around this capacity.

In this area there are two basic types of compressors: positive displacement, and turbocompressor. Main distinction is in the energy transfer method: in positive displacement the fluid is compressed by the varying volume of the container; in turbo machines the pressure comes from dynamic effects such as centrifugal force.

Depending on the principal direction of the gas flow through the machine, turbocompressors are axial-flow and radial or centrifugal-flow machines, with intermediate mixed-flow types employing varying combinations of axial and centrifugal flow.

continued, next page

ADIABATIC HEAD
selects compressor type



ADIABATIC HEAD for the compressor, when pressure ratio is known, is computed from the values read on the vertical scale.

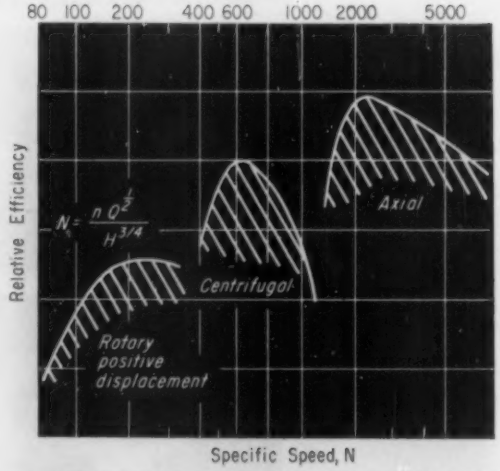
Positive Displacement

Positive-displacement compressors include reciprocating machines such as piston and diaphragm types, and rotating machines of the vane, gear, screw and lobe types. Pressure rise in such machines requires small clearances plus some method of lubrication, and the compressed gas therefore may be subject to contamination by the lubricant. However, some special reciprocating or vane-type compressors with carbon piston rings or carbon vanes are designed to run without lubricating oil.

Piston-type reciprocating compressors are available in great variety, including special machines for unusual requirements. Maximum compression ratio is 10 per stage; two-stage compressors are available for compression ratios greater than 8; multistaging can produce discharge pressures up to 5000 psi.

Diaphragm-type compressors are limited to a flow of only a few cfm; low initial cost is offset by limited life and frequent maintenance under severe service.

Rotary sliding-vane compressors can produce a com-



SPECIFIC-SPEED RATIO compares the efficiency of all three types of compressors for a given speed, volume and adiabatic head.

pression ratio of about 8 per stage. They perform efficiently over a wide range of pressure and flow rates, particularly for pressure ratios of 2 or greater.

Liquid-piston compressors employ water or other low-viscosity liquid to compress gas trapped between the blades and casing wall. There is no metal contact between blades and wall, therefore no lubrication or wear at these points. Single-stage compressors are available for a wide range of flow capacities, with compression ratios up to 5.

Gear-type compressors have two meshing-screw rotors to produce internal compression. Timing-gears maintain a fixed clearance between the rotors and no internal lubrication is needed. Pressure ratios of 3 are possible with inlet at atmosphere.

Rotary two-lobe compressors have mating lobed impellers that push the gas from inlet to discharge line. No internal compression takes place, but the impeller forces the gas through the discharge opening against back pressure of the system. As in the screw-type rotor, clearance between impellers is fixed by timing gears, thus eliminating need for internal lubrication. Compression ratios are limited to about 1.7 in a single stage.

Usual limiting pressure ratios per stage for various types of positive-displacement compressors in capacities up to 1000 cfm are:

Type	Max Pressure Ratio
Piston	10
Vane	8
Liquid piston	5
Diaphragm (10 cfm max)	5
Screw	3
Lobe	2

Adiabatic-head Equation

Operating characteristics of all types of compressors can be compared by the combined use of two parameters—specific speed and adiabatic head—each a function of the geometry of the machine. Specific speed is a dimensionless ratio first developed for liquid pumps and then applied to compressible fluids:

$$N = nQ^{1/2}/(gh)^{3/4}$$

For liquids, h is simply pressure × density. But for compressible fluids, h must be integrated for density change in the compression process, using the thermodynamic description of a reversible adiabatic process, and becomes the "adiabatic head" H:

$$H = \frac{R\,(T + 460)}{\frac{K-1}{K}\,M}\left[\left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}} - 1\right]$$

or

$$\frac{HM}{T + 460} = f\left(K, \frac{P_2}{P_1}\right)$$

This relationship, presented graphically in the "adiabatic head" curves (facing page) expresses compressor performance in terms of: pressure ratio of the machine, fluid inlet temperature, molecular weight and ratio of specific heats of the fluid. The relationship can be used to determine the adiabatic head needed for a given application, or to evaluate a specific compressor from catalog performance data.

In a centrifugal or axial-flow compressor, H is determined by the speed, impeller diameter and vane geometry. In a positive-displacement machine, H is determined by the volume change in the fluid space during the compression stroke. Thus, this factor is a useful constant in

GAS PROPERTIES FOR COMPUTATION OF ADIABATIC HEAD

	Molecular weight	Ratio of specific heats*
Hydrogen	2	1.4
Helium	4	1.7
Methane	16	1.3
Ammonia	17	1.3
Steam	18	1.3
Nitrogen	28	1.4
Carbon monoxide	28	1.3
Air	29	1.4
Oxygen	32	1.4
Carbon dioxide	44	1.3
Freon 12	121	1.1

* Values are for input temperatures in the normal ambient range.

SYMBOLS

- g = gravitational acceleration
- h = pressure head, ft
- H = adiabatic head, ft
- K = ratio of specific heats of gas for ambient temperatures
- M = molecular weight of gas
- n = rotational speed, rpm
- N = specific speed
- P_1 = compressor inlet pressure, psia
- P_2 = compressor outlet pressure, psia
- R = gas constant, 1544 ft lb/lb/deg Rankine
- T = inlet temperature, °F
- Q = volume, cfm

evaluating the capability of any compressor under given operating conditions.

Further, the adiabatic-head concept helps evaluate the effect of varying the fluid properties, inlet pressure and inlet temperature on compressor performance. For a given machine,

- An increase in inlet temperature decreases the pressure ratio
- Change in inlet pressure produces a proportional change in discharge pressure
- Change to a gas with higher molecular weight increases the pressure ratio

Since this relationship applies to both positive-displacement and turbocompressors, it offers a direct method of comparing performance in a specific application. When specific speed is plotted as:

$$N = nQ^{1/2}/H^{3/4}$$

as shown in the diagrams, the relative efficiency of positive-displacement, centrifugal and axial-flow machines is readily evaluated for a specific speed, flow and head.

In using this method to select a machine for a specific application, the first step is to define the system requirements:

- Molecular weight and ratio of specific heats for the gas
- Pressure ratio required, including system losses
- Inlet gas temperature
- Flow rate

Next determine the optimum type of compressor by these steps:

- Calculate adiabatic head H from curve
- Decide on speed
- Calculate specific speed
- Select compressor type from chart

If chart indicates positive displacement, use pressure ratio to narrow the choice.

While pressure ratio, flow and speed are the primary factors in selecting a compressor, the decision must also consider pressure losses in the system, and uniformity

SOME EXAMPLES

Now, let's carry through a simple problem. Suppose we need 50 cfm of room air at 2 psi, and plan to use an ac universal motor at 20,000 rpm with a life of 1000 to 2000 hr. Molecular weight of air is 29, ratio of specific heat is 1.4. Pressure ratio (absolute pressure) is 16.7/14.7 or 1.136. From the adiabatic head curve, HM/T is 200, and H is 200 x 530/29 or 3680.

Substituting this value for H in the equation for specific speed gives $N = 20{,}000\ (50)^{1/2}/3680^{3/4}$ or 300. Turning to the chart for specific speed, this value falls between the displacement and centrifugal types. A centrifugal type can be made at relatively low cost from aluminum stampings, while a positive-displacement compressor needs more parts, closer tolerances and therefore costs more.

If the application were industrial, requiring a service life of 5,000 or 10,000 hr, problems of brush wear and bearing life in a universal motor could be eliminated with a 3600-rpm induction motor. At this lower motor speed the specific speed would be 55, and the choice would now swing to a vane-type compressor, which would also be much quieter.

To show how this design approach works with another gas, consider a machine to compress 400 cfm of carbon dioxide from 5 psi and 100 F to 85 psi, with a compressor rotating at 3600 rpm. Molecular weight of carbon dioxide is 44 and ratio of specific heats is 1.3. Pressure ratio (absolute) is 5. Entering the adiabatic head curve from the pressure ratio, the value of 3000 is read on the ordinate. Adiabatic head H is 3000 x 560/44 = 38,200. Specific speed is $3600(400)^{1/2}/38{,}200^{3/4}$ or 26, at the low end of the positive compressor range. Since the pressure ratio is 5, either a piston or vane type can be considered.

The flow would have to be increased by a factor of 500 or the rpm multiplied by 10 before a centrifugal compressor would be effective.

Performance data in catalogs is generally given in terms of air at room temperature and atmospheric pressure. The adiabatic head chart can be used to find the equivalent performance for air instead of carbon dioxide. Adiabatic head H will be the same, 38,200. Molecular weight of air is 29, inlet temperature 520R, inlet pressure 14.7 psi, and ratio of specific heats 1.4. Therefore

$$HM/T = 38{,}200 \times 29/520 = 2130$$

Entering the chart for adiabatic head at 2130, and K at 1.4, the pressure ratio is 3.2, and outlet pressure is 47.0 psia. Therefore, a compressor designed to deliver 400 cfm of air at 47 psia with 60-F inlet air temperature would compress 400 cfm of carbon dioxide from 20 psia to 100 psia at an inlet temperature of 100 F.

Or take an extreme example, helium with a molecular weight of 4 and a ratio of specific heats of 1.66. Assume the compressor is to take helium at 80 F and 50 psig and deliver 75 psig. Pressure ratio (absolute) is 1.39. From the adiabatic head chart, the vertical scale value is 520. With $T = 540$ R, H is calculated 70,200.

Translating these values to air as a base ($T = 520$ R, $K = 1.4$, and $M = 29$) using the value of H calculated for helium; the new ordinate is

$$70{,}200 \times 28.95/520 = 3910$$

This value, read down from the curve for $K = 1.4$, gives a pressure ratio of 6.8. Therefore, a compressor designed to deliver a pressure ratio of 6.2 in air with an inlet temperature of 60 F would compress the same volume of helium to a pressure ratio of 1.39 with an inlet temperature of 80 F and inlet pressure of 50 psig.

of load; corrosiveness, dirt and moisture content of fluid; service life and maintenance problems.

A compressor system must provide the required flow and pressure at the discharge of a pneumatic system, which includes pipe, valves, and fittings. Methods for estimating system pressure losses are described in reference texts, and articles such as "Pressure Losses in Pneumatic Systems" (*PE*—Oct 26 '59, p 50).

Provision should also be made for additional flow capacity for potential growth. Additional components are almost invariably added—an allowance of at least 25% over immediate needs, depending on the situation, will call for little increase in investment. Also, compressor performance decreases with age and use, primarily from wear of vanes, valves or piston-rings. This shows up as a decrease in discharge pressure, rather than a decrease in flow.

While there is no hard-and-fast rule, in general, the system should be designed for one additional pressure ratio. For example, a system discharging at 100 psi (gage) with atmospheric inlet (a pressure ratio of approximately 8) would need a pressure ratio of 9 and a discharge pressure of approximately 120 psi. Again, the additional investment is minor.

For a system with an intermittent load—the more common case—the compressor capacity should be less than the system capacity, with the difference made up by an accumulator in the system. If some variation in supply pressure is acceptable, a relatively small compressor can be used with a large accumulator. If the supply is used for long periods of time with only short idle periods, compressor capacity should nearly equal the supply. If a relatively constant discharge pressure is required, use a small accumulator and a large compressor. For regulated pressure, use an oversize compressor with a pressure regulator.

For Specialized Requirements

Other requirements include corrosive gases, wet gases, high temperatures, high pressures or extremely low pressures, as well as gases of differing physical properties. For high pressures and very low vacuums, a range of heavy-duty high-pressure compressors and close-clearance high-suction compressors is available. For corrosive applications, the compressor surfaces in contact with fluid may be glass, stainless steel, or graphite.

Wet gases, and gases other than air, influence selection. Compression of wet gases leads to a more nearly isothermal compression with a consequent change in compressor performance; lubrication may present problems not present with dry gases. Corrosion-resistant construction may be needed for high-temperature gases; or the choice may be between an expensive specialized compressor or use of cooler to decrease the inlet temperature. But these specialized compressor conditions often present problems that only the compressor manufacturer can solve, and the requirements should be discussed with him.

Compressors—in Series or Parallel

When additional flow or pressure is needed beyond the capacity of an available compressor, within certain limitations compressors can be operated in parallel or in series. In series, matching problems arise in positive-displacement machines—piston, rotary vane, rotary lobe.

If two of these compressors are operated in series the discharge flow rate of the first must match inlet flow rate of the second. If not carefully matched, a series system may show an appreciable vacuum or excessive pressure between the two compressors rather than the intermediate pressure desired. Mismatch may also introduce seal problems in the second compressor, since inlet and discharge pressure, and the compressor-case pressure, will be higher than design values.

With turbocompressors in series, a flow mismatch will cause surging of one or the other, and flow instability.

Positive-displacement compressors can be operated in parallel if the discharge pressures of the two machines are about the same; flow through one compressor has little or no effect upon the other. However, turbocompressors operated in parallel do present a matching problem; one compressor will frequently pick up the entire flow while the second idles or becomes unstable. Consequently, an automatic flow-control system is required.

Turbo and positive-displacement compressors can be combined; a turbocompressor can be used as a supercharger ahead of a positive-displacement machine, or vice versa. Or a turbocompressor could be used in parallel with a positive-displacement compressor as a flow booster.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, NY.

EDITOR'S NOTE: Practical considerations in selecting large compressors are discussed in this previous article:

Selection and Application of Heavy-duty Compressors, Mid-Sep '58, p J-12, gives tips for selection, installation, cooling, driving, staging and pricing of single and two-stage reciprocating compressors.

Properties of air and its behavior in systems are thoroughly treated in:

New Data for High-pressure Air, Sep 14 '59, p 71, gives compressibility, specific heat, viscosity, and velocity of sound for air from zero to over 5000 psia.

Pressure Losses in Pneumatic Systems, Oct 26 '59, p 50, summarizes and expands the NBS flow-factor technique, giving tables, nomographs and calculated examples for complete piping systems.

Pressure Drops in Air Valves, Apr 14 '58, p 74, a summary of most known methods to calculate pressure losses, featuring a simplified K-factor that gives answers directly in static pressure.

what the designer should do about PRODUCT PRICING

You can't separate design and price, yet engineers are rarely told about the marketing plans for a product. Here a marketer tells what engineers should know.

DR ALFRED R OXENFELDT

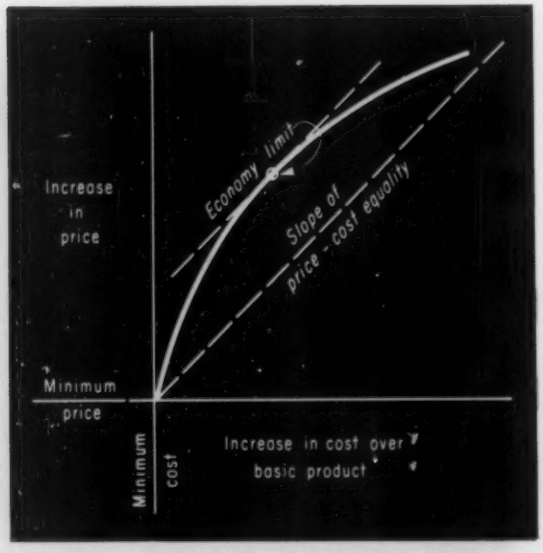
Professor of marketing
Graduate School of Business
Columbia University

The connection between product design and price is fairly obvious: The better a product's features and design the higher the price it will command. Conversely, a product that suffers in comparison with its competitors must be sold at a lower price, if at all.

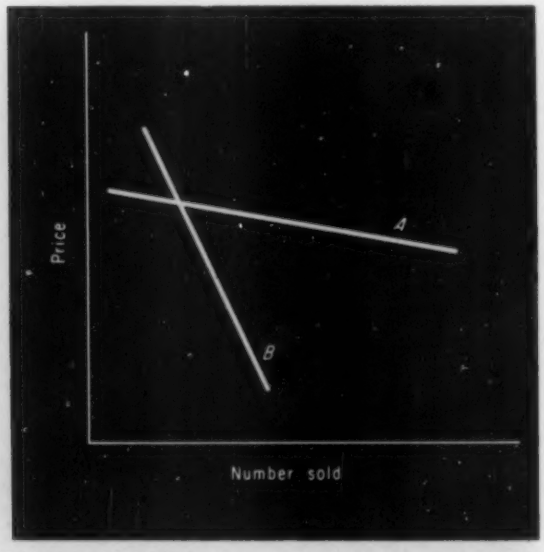
A designer's major function is to discover or create features in products that buyers will pay to own—and pay more than it costs to make them. Yet in few firms is the designer asked his opinion about price. Often he does not recognize his own place in the pricing process.

The extreme views

To the designer it would seem simplest to design the best product possible—and let others determine the price. This takes economics out of designing, but, except for a few rare instances (medicine, space ships, and the like), it is impractical. Almost no market exists for the best pos-



RATIO OF INCREMENTS OF COST AND PRICE is the best index of probable profit. Starting with a basic product —having minimum quality to perform a function—each increase in quality has a measurable manufacturing cost. As long as the permissible price increase is larger than the cost increase, quality is a profitable investment.



PRICE ELASTICITY is an index of how changes in price affect sales. Products may differ greatly in this respect. Here product A shows extreme price sensitivity—a small change in price results in a large change in the number sold. Conversely, product B sales are relatively insensitive to price changes.

sible product. Customers usually want a less perfect product at a substantially lower price.

The nearly perfect can be made and sold—for art's sake, or prestige, or because there is no alternative to perfection—but then the few customers that exist for such things know they are buying perfection and price is unimportant.

Alternatively, marketing can set a price and then require the designer to produce the best product possible for that price. This is more common—but almost as unrealistic as setting no price limit.

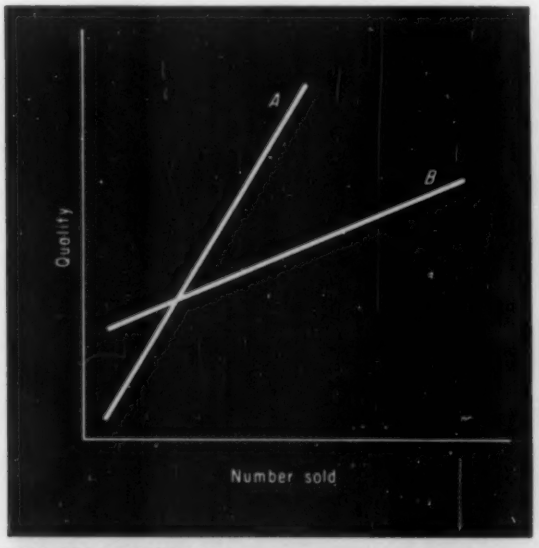
No one price is "ideal" for a product. Change its features, improve its design, and, within limits, it will be possible to raise the price. More important, all features are not of equal value when it comes to attracting customers.

It is clear that the designer must balance the costs of improvements against the added price and altered volume they will cause. Savings and increased volume, by eliminating the least attractive features, are also legitimate obligations of every designer.

A clear-cut customer

You can't sell your product to everyone. This is basic to product engineering and pricing, yet is often ignored or overlooked. No single type of auto, shoe, paint, lawnmower, engine lathe or lamp bulb, can serve the needs of all customers best. Even where the product would serve two different customers best it may be much harder to sell it to one than the other because some nonfunctional attributes are valued even more than the functional ones.

It is essential, therefore, to select your customer first—before design starts and certainly before pricing starts.



QUALITY SENSITIVITY measures sales change as a result of quality change. Some products—cosmetics, health products, high-prestige items—respond strongly to improvements in quality (line B, above). Others are not likely to respond to small changes in quality. Product A produces little increase in sales with increasing quality.

And the designer, the advertising department, the sales force, and those responsible for pricing and credit policies all should have the same customer in mind.

A specific product type

Economists have long recognized that buyers' sensitivity to price varies from product to product. This sensitivity is called the "price elasticity of demand."

Similarly there is what might be called a "quality elasticity of demand"—just how much buyer sensitvity is there to each added feature? How important would a faster airplane ride, a higher fidelity radio, a more efficient auto engine be in stimulating sales?

Price and quality sensitivity do not necessarily coincide. They must be determined individually for each product.

What you need to know

The interaction of customer type and specific product (with varying features), if fully understood, can provide all the data needed to determine what design and price will most closely achieve the goals of management. Note that maximum profit, prestige, or full utilization of capital resources may each call for a different product or product line (see *PE*—Oct 19 '59, p 34).

You must know:

1. What kind of customer is envisioned. How many are there?
2. What product features or quality interest this customer?
3. How much does each version of the product cost to make?
4. How important is price to the customer?
5. How important are quality or added features to the customer?

It is not the designer's task to accumulate this information, but it is necessary for him to request and evaluate it. He should ask: Has the customer been clearly defined? Have his wants and preferences been established from a reasonable sample with fair accuracy? If the product is new or unfamiliar to potential customers, have the product features been clearly described in the survey by photograph or sample? Is there a difference between immediate and long-term reaction? What is the reaction to competitive products; what features do they have and at what price?

What the designer can do for the pricer

His basic responsibility is to produce desirable features at low cost. His next responsibility is to "segment the market," that is, to include something special in the line of products for all important types of buyer, considering both the utility and the luxury buyer. (A minimum price can-opener won't interest a lady who wants a motor-driven opener in the latest fashion colors.) The designer who tries to satisfy widely different customers with the same product design puts an enormous burden on the sales organization.

As price rises, appearance has more influence on the customer. Products must catch the eye, compete with similarly functioning products, and look their worth or more. That's a challenging assignment, but it can be a very satisfying one. ■

designing

HIGH-IMPACT PHENOLIC MOLDED PARTS

Adding fiberglass reinforcement can make conventional phenolic resins a strong competitor to metals where shock loads are a problem. But the design criteria you use for unfilled phenolics don't apply here. Author gives new rules, based on latest industrial experience with these materials.

MINERT E HULL, *supervisor*
Molding Research and Development
Durez Plastics Div
Hooker Chemical Corp

Phenolics cannot be considered structural plastics until they are reinforced, even though their uniquely plastic characteristics make them ideal for many industrial applications. This is because the impact strength of the unreinforced phenolic is too low for products where shock loads are routine—pump housings, transmission clutch rings, gears, and rocket nozzles, for example.

By reinforcing with glass fibers, usually in the form of chopped roving ½ to 1 in. long, the notched-impact resistance of phenolics is raised to well over 2 ft-lb/in. of width. This creates a class of materials that can be called "high-impact" in accordance with military specifications, and opens the door to replacing many metal parts—while adding a host of advantageous properties other than structural strength: thermal and chemical resistance, dimensional stability, electrical and acoustical insulation, and chemical resistance.

Design Rules for Minimum Cost

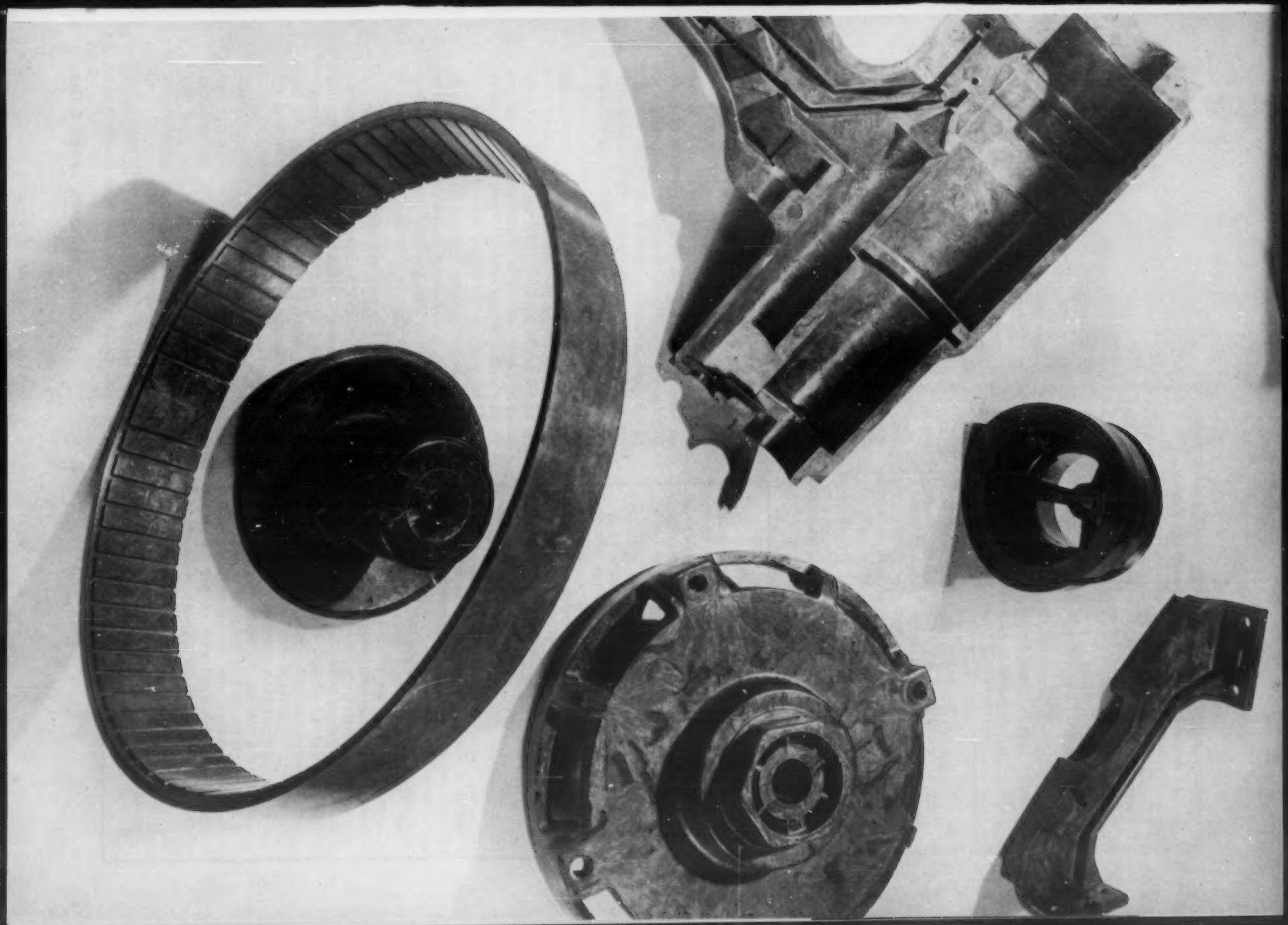
The usual design practices for conventional unreinforced phenolics, while providing a good start, will not give maximum performance at minimum cost. Recent experience with the high-impacts by molders and materials suppliers has shown that for these materials design is different. Based on this experience, here is a summary of good design practice:

Dimensional accuracy should be controlled primarily by correct choice of reinforcement, which influences part shrinkage—both as-molded and aged. Glass fibers give best control because zero shrinkage can be obtained (Table I, p 56). Reasonable tolerances of ±0.001 in./in. and finer tolerances are possible through precise control of mold temperature and pressure. Here, a zero-shrinkage mix is used, but size of the metal mold—which varies slightly with temperature and pressure—controls preciseness of the part. This explains the ±1 mil tolerance shown in the table for the zero-shrinkage material.

Taper required in a mold is related to the molded shrinkage of the plastic used. Since glass-filled phenolics can be furnished with zero molded shrinkage, molds can be built with no taper when necessary. Cylinders up to 12 in. dia and 18 in. deep have been produced. A taper of ¼° to

text continued on page 56

THESE 6 IMPACT PHENOLIC MOLDINGS	DESIGNED FOR THESE SHOCK ENVIRONMENTS
1 Stud-welding gun	Dropping in use
2 Rocket nozzle	Thermal shock
3 Compressor support	Vibration
4 Motor end-bell	Factory abuse
5 Clutch cone	High friction
6 Washer sheave	Reversed torque



I—SHRINKAGE LIMITS FOR HIGH-IMPACT PHENOLICS
(measured at 72 F)

Shrinkage type	Glass-filled		Cellulose-filled		Mineral-filled
	1-stage	2-stage	1-stage	2-stage	2-stage
As-molded, mils/in. . . .	0(±1)	0–1	3–4	2–3	0–1
Post-molded, mils/in. . .	0–1	0–1	2–3	1–2	0–1

II—MINIMUM WALL AROUND INSERTS

Insert OD, in.	Plastic wall thickness, in.
1/8	5/64
1/4	9/64
3/8	5/32
1/2	3/16
3/4	1/4
1	9/32
1–1/4	5/16
1–1/2	11/32
1–3/4	3/8
2	13/32

III—MECHANICAL PROPERTIES COMPARED
(measured at 72 F, with ASTM specimens)

Property	Phenolic			Polyester
	(>30% glass)	(mineral-filled)	(cloth-filled)	(>20% glass)
Notched impact, ft-lb/in.	9–24	2–4	2–5	6–15
Flexure strength, psi×1000. .	12–80	15–18	10–15	12–25
Flexure modulus, psi×10^6. . .	3.0	2.5	1.4	1.6
Specific gravity	1.8–1.9	1.9–2.1	1.8–2.0	1.8–2.0

WHAT ARE HIGH-IMPACT PHENOLICS?

These materials consist primarily of phenolic resin and a reinforcing filler with colorants, lubricants and modifying fillers in proportions designed to furnish the required molding characteristics and properties in the finished part. Glass fibers are the most common fillers for maximum impact resistance. Other reinforcements are: sisal fibers, chopped cloth, cotton, or asbestos cord.

Usually supplied to the molder in the form of dry, preimpregnated glass fibers, the high-impacts use two basic types of phenolic resins—depending on storage characteristics desired:

One-stage resins have the shorter storage life because they are prepared in one operation from at least one part formaldehyde, one part phenol and an alkaline catalyst. These resins are heat-sensitive and advance slowly at room temperature. Materials prepared from these resins are stored below 40 F, because their shelf life is from 1 to 6 months at room temperature.

Two-stage resins are designed for longer storage by adding formaldehyde to phenol in two steps. First one part phenol and less than one part formaldehyde are reacted with an acid catalyst to produce a brittle resin. This is pulverized with hexamethylenetetramine which, under heat, provides the extra formaldehyde needed to cure the resin. Materials compounded from two-stage resins can be stored for years at room temperature and still retain their molding properties.

Compression molding at 280 to 350 F under 2 to 10,000-psi pressure in full positive molds is the recommended practice with these materials. Transfer-molding techniques are avoided because they result in destruction or alteration of the reinforcing filler, with subsequent loss of strength. Since uniform fiber distribution is essential, parts are designed to provide unrestricted flow in the molding operation.

1° is desirable for ease of ejection from molds with over 4-in. depth of draw.

Wall thicknesses have varied from $\frac{1}{16}$ in. to several inches. Preferably, walls less than $\frac{1}{32}$ in. should be avoided on parts requiring long and deep flow. Thicknesses over $\frac{1}{2}$ in. require special molding technique, but sections up to 4 in. have been made. Over-all size of parts is limited only by capacity of available presses. Parts weighing several hundred lb and 3 to 6 ft. in height and diameter have been produced.

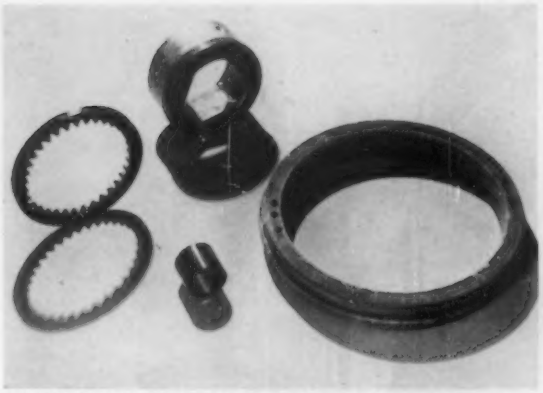
Fillet radii should be used to minimize stress concentration in high-impact phenolic moldings, no matter what the type of reinforcing filler. The radius should not be less than $\frac{1}{8}$ in. and should be $\frac{1}{4}$ in. or as much more as the part design permits. Square corners or radii less than $\frac{1}{8}$ in. should be used only where absolutely necessary.

Inserts used to provide threaded holes for assembly should have a coarse diamond knurl for maximum anchorage. Any metal is suitable. The plastic wall thickness around an insert depends primarily upon insert OD, as shown in Table II.

Holes can be molded or drilled. Molded are best and should be in direction of the molding force. Length of the mold pin producing the hole should be no more than twice its diameter, up to 2 in. For a side hole, perpendicular to the molding force (material flow), the pins should be activated. Holes should be spaced from the edge of the part according to their size, following the rules for inserts. Holes can be molded part-way through and finish-drilled.

Threads should be tapped, not molded, and no coarser than 32 pitch. Their depth should be three times their diameter. Machine-tapped threads are 50% stronger than those made with self-tapping screw.

Stiffeners, such as ribs, bosses and the like, normally are not required for glass-reinforced phenolics because modu-



DIMENSIONAL STABILITY, both as-molded and aged, is a key feature in designing these high-impact moldings. Clockwise: oil-pump gear must retain dimension as lubricant temperature rises; spline fits inside metal cover with no pull-away because of close shrinkage control with resin; slip ring is molded in place in zero-shrinkage resin to prevent separation; aircraft sleeve bearing is molded around liner of Teflon cloth to give strength and tolerance control.

lus is high and because zero molded shrinkage precludes warpage.

Surface finish of any mold will be reproduced very exactly. Molds must be highly polished and free from undercuts or the reinforced phenolic will not release, because it has little or no molded shrinkage. The molded surface will be completely free of ripple finish when the molding pressures used provide maximum density and the material used has zero molded shrinkage.

Choice of color of high-impact phenolics is limited. These phenolics are normally supplied in a natural tan or brown color, which will darken with age or on exposure to sunlight. This does not affect the properties of the material. Epoxy-based paints have been developed which adhere very well to phenolics and are specified when the dark phenolic part must have another color.

Labelling parts produced from high-impact phenolics is best done by molding in the numbers of identification desired. Stenciling or painting, using epoxy paints, also are common methods.

Specifying the Material

Although the above design rules are drawn mainly from practice with fiberglass-reinforced phenolics, they can guide the design of mineral- and cellulose-filled parts. Table III shows how much shifting from glass to these reinforcements can affect mechanical properties. Note too, that shrinkage increases sharply when cellulose (usually as chopped cloth) is specified, Table I.

Choice between cellulose and mineral filling hinges on environmental factors, as well as shrinkage differences. Here is a useful rule of thumb when considering environment: For dimensional stability under conditions of heat or humidity (or both), specify mineral-filled impact phenolics; where low sound transmission or low heat transfer are desired, choose the materials filled with cellulose or synthetic fiber; for high-temperature insulation purposes, mineral-filled impacts are best.

Whether the molding material is prepared with one-stage or two-stage resins (see "What Are High-impact Phenolics?") has a bearing on environmental performance too: one-stage materials generally have better moisture and chemical resistance, while two-stage materials have the advantage of offering superior electrical and dimensional stability properties.

A word about property data. Materials suppliers normally base properties on tests of standard ASTM specimens. When molded from high-impact phenolics, these specimens have a certain degree of favorable fiber orientation—while actual parts have primarily random orientation. Specimens cut from them will thus give lower mechanical properties than the same material in a standard ASTM piece. This is particularly true of glass-reinforced materials, polyesters as well as phenolics. (Some suppliers compensate by molding a test slab under the same conditions as the part to be made.) Because of this tendency for standard figures to be unrealistically high, a safety factor of 3 to 4 is recommended.

A Look Ahead

The use of reinforced plastics in space vehicles and missiles for structural purposes or heat resistance has led to development of a class of materials based on new fillers and resins. High-purity silica fibers and cloth, quartz fibers, graphite cloth, and synthetic inorganic fibers compounded with special phenolic resins have shown outstanding resistance to temperatures of 3,000 F-10,000 F for short periods. The technological advances brought about by these developments should provide a base for improved high-impact phenolic materials in commercial applications.

ACKNOWLEDGEMENT: The author thanks Durez technical staff members Edward F. Borro Sr and Robert W. Bainbridge for their assistance in preparing this article.

EDITOR'S NOTE: The following recent articles cover other aspects of design with phenolics, both filled and unfilled:

Postformed Phenolics, Feb 17 '58, p 66—shaping parts from prelaminated sheet stock is often cheaper than molding and laminating simultaneously. Article gives design rules.

Sandwich-panel Facing Materials, Apr 28 '58, p 80—second of three articles on modern industrial sandwich structures describes materials that make the skins, with ready-reference chart for properties.

For Better Phenolic Molded Parts, Sep 1 '58, p 44—article brings together in one handy reference source the key rules for correct design. Covered are: shrinkage, tolerances, part geometry, inserts, surface finish, marking, color, etc.

Selecting Plastic Laminates for Punching, Feb 2 '59, p 57—ready-reference chart relates punching ease of various laminates, including several phenolic grades, with their mechanical and electrical properties.

Comparison of Phenolic and Polyester Premix Materials, Mid-Sep '59, p C-12—presents detailed data on composition, cost, and properties of two highly competitive materials for replacing metal parts.

More Work for High-temperature Reinforced Plastics, Nov 23 '59, p 58—author interprets a steadily growing body of data based on ultrahigh-temperature testing of phenolic laminates and other heat-resistant materials for missiles and rockets.

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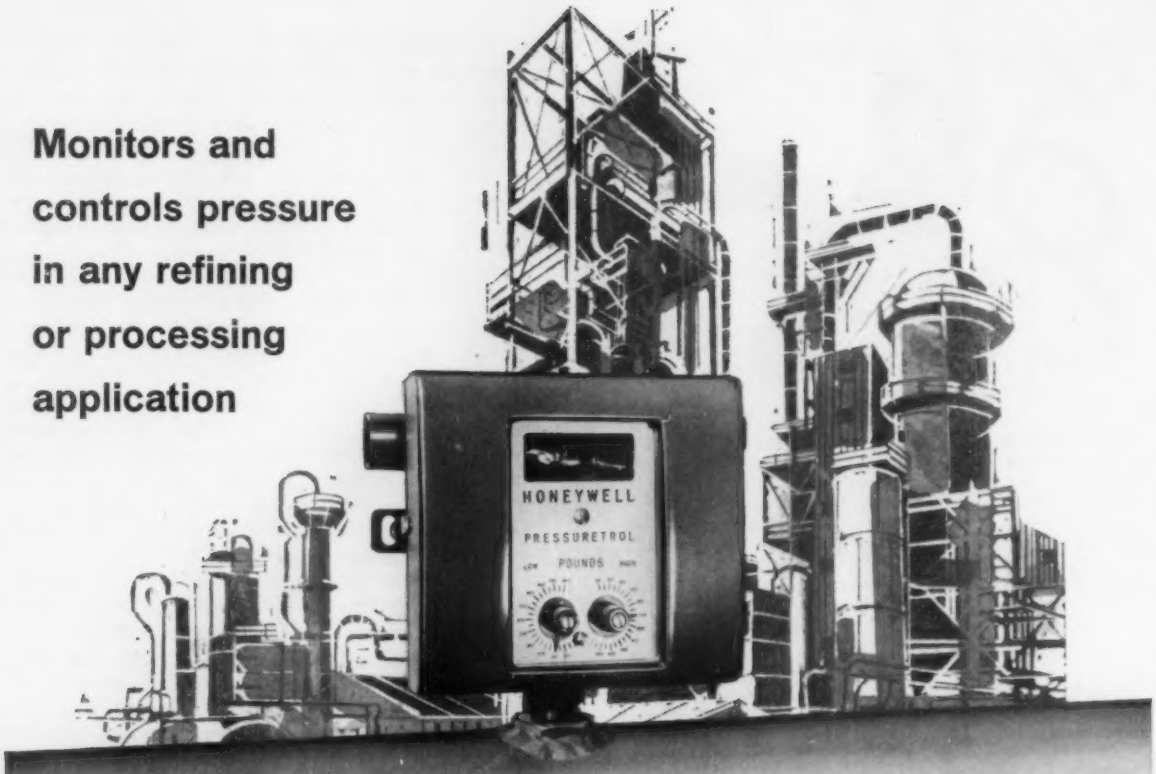

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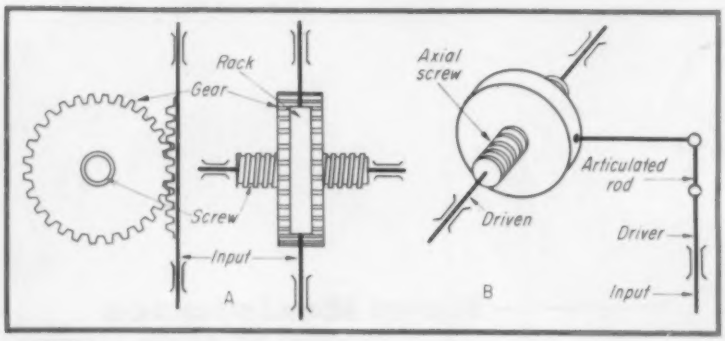
9 more ways to CHANGE STRAIGHT-LINE DIRECTION

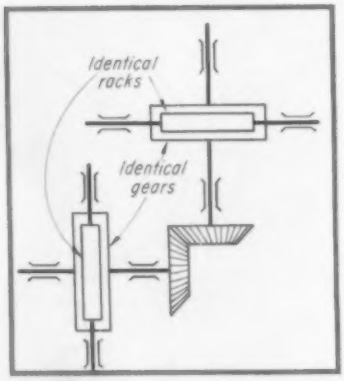
These devices, using gears, cams, pistons, and solenoids, supplement 10 similar arrangements employing linkages, slides, friction drives, and gears, shown in last week's issue.

FEDERICO STRASSER
Mankowitz & Strasser Ltd
Santiago, Chile



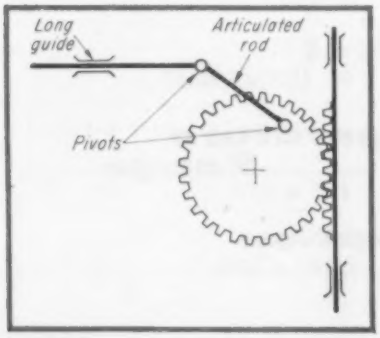
1

Axial screw with rack-actuated gear (A) and articulated driving rod (B) are both irreversible movements, i.e. driver must always drive.



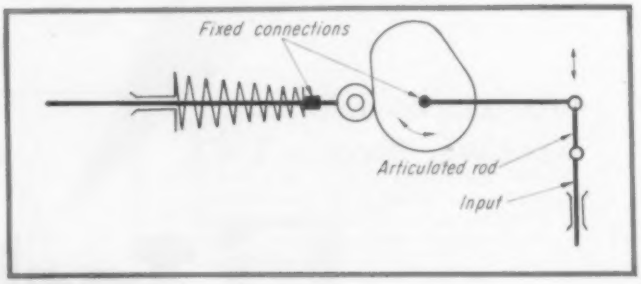
2

Rack-actuated gear with associated bevel gears is reversible.



3

Articulated rod on crank-type gear with rack driver. Action is restricted to comparatively short movements.



4

Cam and spring-loaded follower allow input/output ratio to be varied according to cam rise. Movement is usually irreversible.

continued on page 61

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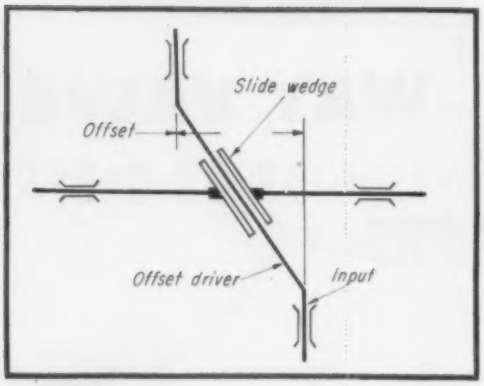
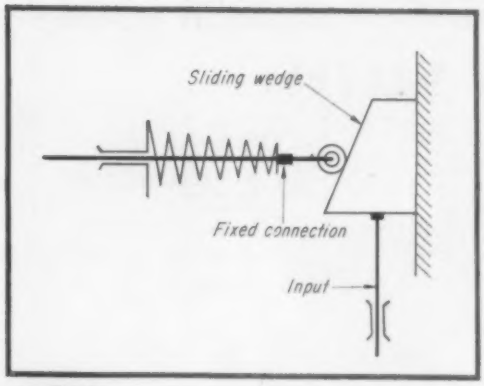


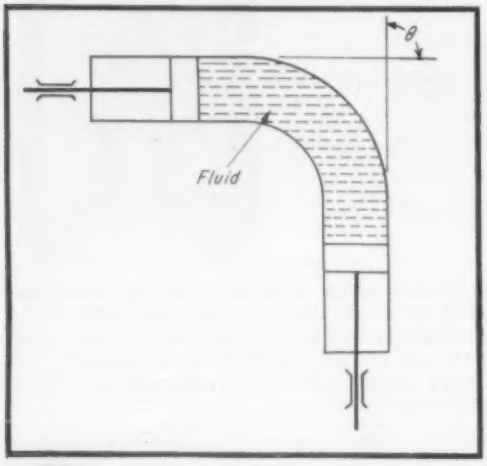
5

Offset driver actuates driven member by wedge action. Lubrication and low coefficient of friction help to allow max offset.



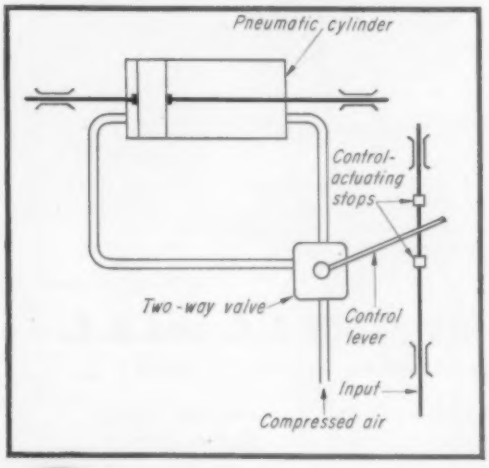
6

Sliding wedge is similar to previous example but requires spring-loaded follower; also, low friction is less essential with roller follower.



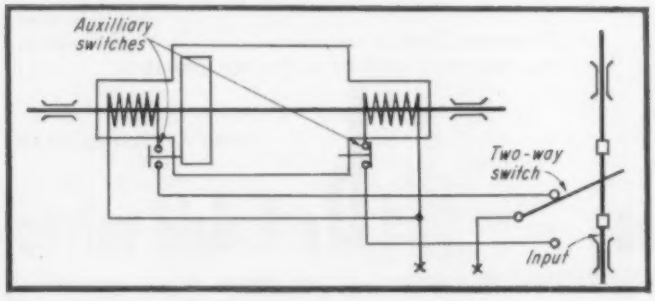
7

Fluid coupling is simple, allows motion to be transmitted through any angle. Leak problems and accurate piston-fitting can make method more expensive than it appears to be. Also, although action is reversible it must always be a compressive one for best results.



8

Pneumatic system with two-way valve is ideal when only two extreme positions are required. Action is irreversible. Speed of driven member can be adjusted by controlling input of air to cylinder.



9

Solenoids and two-way switch are here arranged in analogous device to previous example. Contact to energized solenoid is broken at end of stroke. Again, action is irreversible.

BLAMING COIL BURN-OUT ON THE SOLENOID? THEN TAKE A CLOSER LOOK AT THE **VALVE!**

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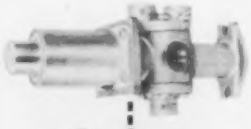

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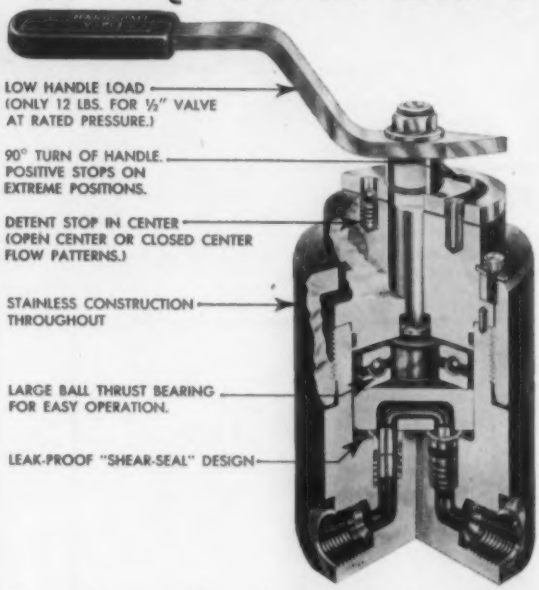
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LEAK-PROOF "SHEAR-SEAL" DESIGN

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No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

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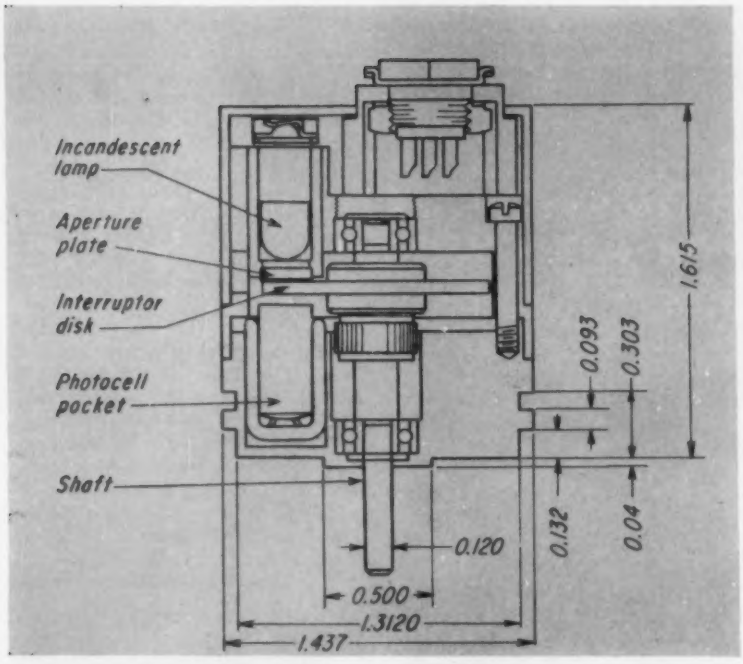

Photoelectric pulse generator . . .

is shaft-driven device that delivers electrical impulses at output terminals. Can be a rate generator or an angle-measuring unit. When used as rate generator, output frequency is read in terms of shaft speed. When used to measure angles, total angle is determined by combining individual pulses. Pulses are generated by light that reaches photocell after passing through rotating disk with alternating clear and opaque sectors. Number of pulses per revolution, therefore, is function of number of segments on disk. Can be supplied with photoresistive or photovoltaic cell. Output of former cell consists of alternations between two levels of internal resistance; output of latter cell is series of dc voltage pulses. Typical output voltage is 0.1 to 0.25 v at 50 k load impedance. Several standard disk patterns provide up to 500 pulses per revolution. Standard unit with one photocell, $275; 30-day delivery. **Industrial Div, W & L E Gurley, Troy, NY.**

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Foam-plastic spray gun . . .

and pumping device sprays two-phase liquid systems, such as polyurethane foams, epoxies, gel-coats and polyesters. Can be used with fast-reacting foam plastics. Reported to have sprayed polyurethane foams with 4-sec reaction times. Uses normal, factory air lines and operates with normal line pressures, 60 to 150 psi. Main air flow drives air motor; small part is bled off for atomizing. One trigger operates both liquid-phase valves and air valve. Pumping device is available with various capacities and multiples of liquid-phase reservoirs. One large unit can operate several spray guns. Basic price of $8700 covers one spray gun, one pumping device (with operating capacity on foam of 0 to 6 lb per min.) and 25 ft of hose for connection. Delivery time, 4 to 6 wk. **Binks Mfg Co, 3114-44 Carroll Ave, Chicago 12.**

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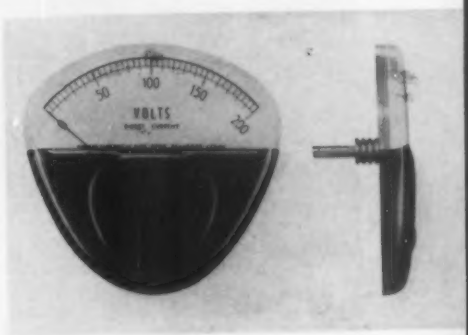


Surface-mounting panel meter . . .

uses printed circuit coil in conjunction with thin ceramic ring magnet. Entire meter is contained in scale housing (¼ in. thick). Nothing projects from rear except terminals, which also serve as mounting screws. Performance is said to be unaffected by external magnetic influence or electrical overload of 1000% for 1 sec. Even indefinite overload will not require readjustment of greater than 1% of full scale. One-milliamp meter withstands overloads up to 5000% under same conditions. Accuracy is said to be better than 1.5% of full scale value at 70 F ambient. Standard 3½-in. models have full scale ranges of 1 milliamp to 500 v. List prices vary from $12.50 to $14. Delivery is initially about 30 days. **Interlab Inc, 437 Fifth Ave, New York 16.**

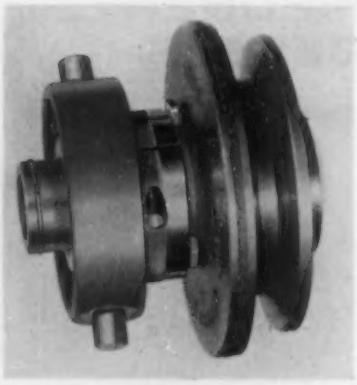
Circle 302 on Reader Service Card

Expanded plastics . . .

are now available in commercial quantities. Polyethylene and polypropylene nonwoven netting is now produced in 22- to 24-in. widths. Both materials, which can be stabilized against degradation by sun's ultraviolet rays, are offered in black, white and a range of colors. Price is 15¢ per sq ft. There are 1.23 yd per lb. Specific gravity is less than one, so the material floats. Breaking strength is 40 psi in filling direction; 100 psi or in more in warp direction. Elongation is 10 to 15% in warp and about 100% downward in filling direction. **Reeves Bros Inc, 1071 Ave of the Americas, New York 18.**

Circle 303 on Reader Service Card

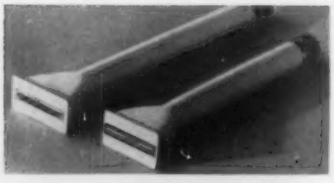
continued on next page



Small disk clutch . . .

has integral single or double V-belt sheaves, mounted on double-seal ballbearings. Clutch is engaged and disengaged with manual shift lever. One model has ballbearing shifter; other has bronze shifter for less severe service. Cam action holds clutch in engaged position. Both takeup adjustment and replacement of asbestos friction disks are reported to be easy to make in field. Stocked in nominal OD sizes of 4½, 4¾ and 5 in. for use with A and B belts having pitch diameters from 3.4 to 4.6 in. For service on keyed stub or through shafts from ⅝ to 1¼ in. dia, at up to 400 rpm. List prices range from $29 to $50. Delivery from stock. **Edgemont Machine Co, 2200 Home Ave, Dayton 17, Ohio.**

Circle 304 on Reader Service Card



Direct electronic printing tube

provides high-speed, electrostatic-charge image formation on nonsensitized paper, plastic or other dielectric material. Cathode-ray tube permits direct conversion of electrical signals into images, either line or continuous tone, made instantaneously visible by selective adherence of pigmented powder or flock. Image may be permanently fixed by rapid-heat process, or erased. Mosaic printing head, composed of orderly array of 0.001-in.-dia metallic elements that penetrate a thin, vacuum-tight glass face plate, replaces phosphor screen usually found in cathode-ray tubes. Printing heads may be up to 12 in.

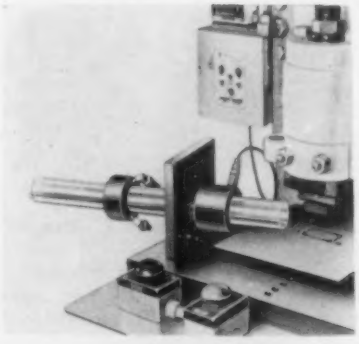
Two models with 2¾-in. writing heads are now available for immediate delivery. Unit with two-dimensional head, 0.15 in. high, accommodates writing of complete characters or symbols across entire head width. Can also be used for sequential scan-line operation. Writing rates of 0.1 microsec per element have been achieved. Component is applicable to facsimile, oscillography, address-labeling and TV-type image reproduction equipment; as well as high-speed computer readout, controlled information storage and erase, multiple-copy reproduction and simultaneous recording at any number of dispersed stations. **Electron Tube Div, Litton Industries, 960 Industrial Rd, San Carlos, Calif.**

Circle 305 on Reader Service Card

Impulse relay . . .

for on-off control of lights, motors, appliances and speakers, has contact arrangements up to DPDT. Rated to 1500 w noninductive, or up to 20 amp locked-motor current, motor-load control on 115 v, 60 cps. Coil voltages are to 230 v ac or 110 v dc. Each momentary impulse, up to 10 steps per sec, causes relay to reverse its cam-actuated contacts. **Guardian Electric Mfg Co, 1621 W Walnut St, Chicago 12.**

Circle 306 on Reader Service Card



Proximity-switch control . . .

is for heavy-duty industrial applications in which dog, pin or air clutch is either electrically operated or can be modified to electrical operation. Unit instantly stops equipment when malfunction is detected (for example, where ferrous or nonferrous metal parts pass through, or by, the detection coil). **Robotron Corp, 21300 W 8 Mile Rd, Detroit 19.**

Circle 307 on Reader Service Card

Miniature acceleration switch

is bidirectional single-axis unit that closes electric circuits in response to preset acceleration level. Automatically resets when acceleration drops below preset value. Consists of gas-damped seismic system with range of ±10 to 30 g, accuracy of 5%, repeatability of 0.5 g, damping ratio of 0.8 of critical and temperature range of −65 to 250 F. SPDT switch normally open, with contact ratings of 100 milliamp each. Weighs 1 oz; measures 1⅛ x ⅞ in. OD. **W L Maxson Corp, 475 Tenth Ave, New York 18.**

Circle 308 on Reader Service Card

Variable-speed drives . . .

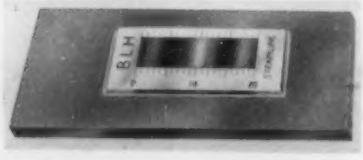
incorporate high-temperature silicon rectifiers, which provide 300% increase in surge safety factor. Operate on 115 v, 60 cps, single-phase supply and provide adjustable dc voltages for driving dc shunt motors. Available for these three motor-size ranges: 1/100 to ⅛ hp; ¼, ⅓ and ½ hp; and ¾, 1 and 1½ hp. Offer regulation of about 4% of base speed; speed range to 50:1; instaneous response and vernier speed adjustment. **Magnetic Amplifiers Inc, 632 Tinton Ave, New York 55.**

Circle 309 on Reader Service Card

10-amp latching relay . . .

operates on 100 milliw minimum. Shock-rated at 50 g, 11 millisec with 30 g vibration, 10 to 2000 cps. Meets specifications of Mil-R-5757C and 25018. Available in DPDT unit with max coil dissipation of 3 w. Min life expectancy is 100,000 cycles at 257 F. Weighs about 1 oz. **Babcock Relays Inc, 1640 Monrovia Ave, Costa Mesa, Calif.**

Circle 310 on Reader Service Card



Near-zero lateral sensitivity . . .

is reported for photoelastic strain gage, a direct-reading uniaxial strain indicator. Indicates axial strain in direction of gage application only. Lateral bending and torque are also indicated. Requires no external instrumentation or connection. Linear displacement of visible interference fringes indicates strain magnitude. Currently produced in two types, with ¾- or 2-in. gage lengths. **Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, Waltham, Mass.**

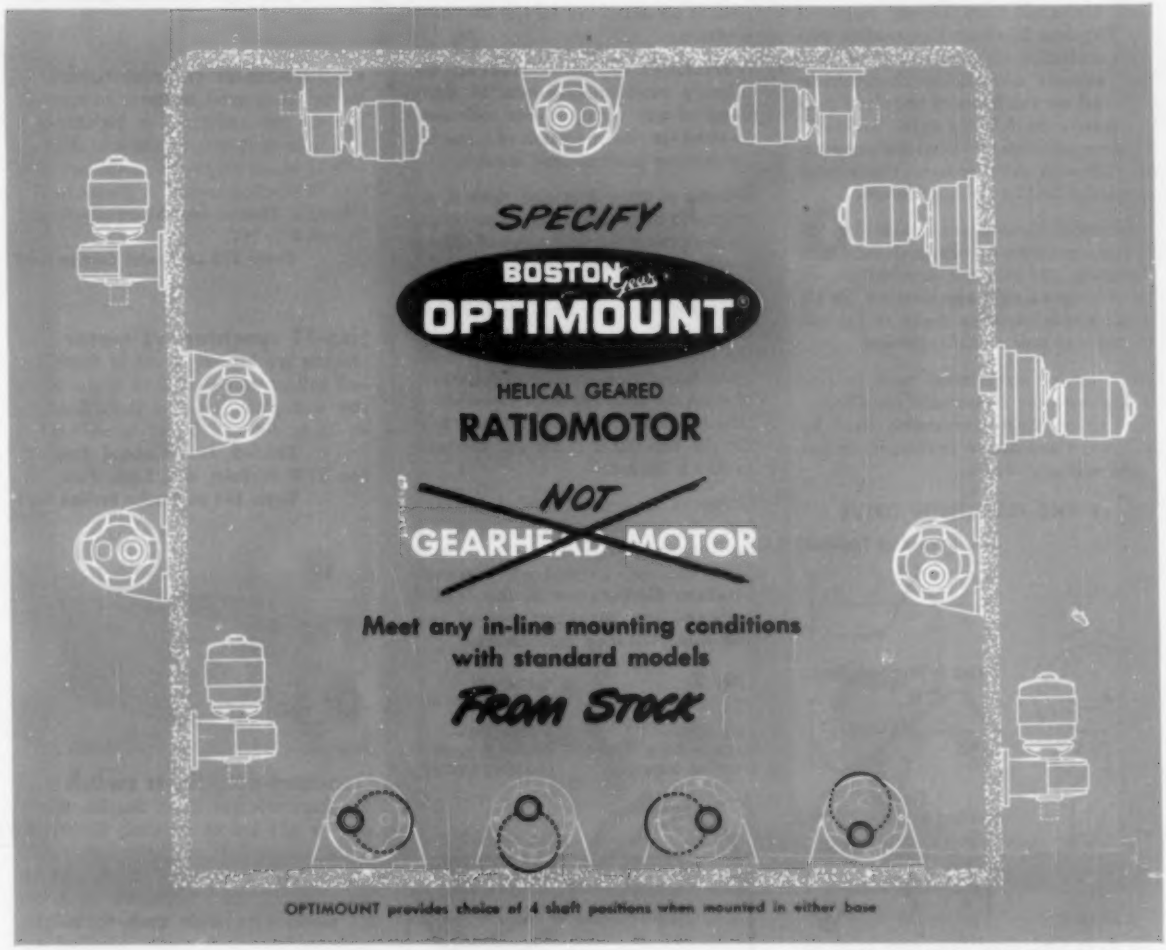
Circle 311 on Reader Service Card

Reverse-current relays . . .

rated 50 to 800 amp, are suitable for industrial applications where severe vibration is present. Lockout coil prevents closing of relay due to vibration when generator is not operating. Relay opens and closes at no more than 0.5 v differential

continued on page 66

How to keep in-line drives in line with today's cost-reduction demands



Advt. copyright by Boston Gear Works

OPTIMOUNT Ratiomotor adaptability opens up endless opportunities for highest efficiency in drives once restricted by the mounting limitations of gearhead motors. With OPTIMOUNT optional mounting, you can choose from 456 combinations and get the arrangement you want, ready to install, FROM STOCK.

You can order horizontal or vertical base mounted — with any shaft position needed — for any floor, wall, or ceiling mounting position. Any size you need, with single or double helical gearing, for 1/6 to 10 hp drives. Motor is readily detachable, can be changed in minutes. You can also order OPTIMOUNT without motor, if desired, ready for attachment of motors you have purchased separately.

Get complete information. Ask for Catalog No. 57. Boston Gear Works, 71 Hayward St., Quincy 71, Mass.

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Get OPTIMOUNT arranged as specified, READY TO INSTALL
FROM STOCK!
at factory prices
Vertical base mounted
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CALL YOUR NEARBY BOSTON Gear DISTRIBUTOR

— STANDARDIZATION PAYS —

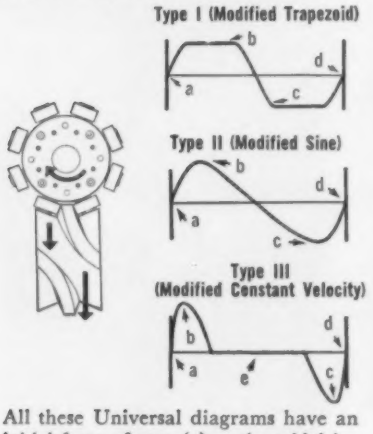
Indexing by SELECTED ACCELERATION for BEST MACHINE PERFORMANCE

The Universal Cam Theory employed by Ferguson Machine Corporation permits utilization of an indexing mechanism with an acceleration characteristic **selected on the basis of required performance** to achieve zero backlash, extreme precision and long, maintenance-free life with the movement characteristics best suited for the application.

Conversely, hit-or-miss methods of specifying a geneva or crank device and accepting the inherent acceleration, or **specifying a single acceleration for all applications,** nullifies many of the advantages of new machine designs.

Any type of acceleration may be employed with the Universal Cam Theory. The three most frequently used by Ferguson are shown below. Each has particular advantages.

FIG. 1 THE FERGUSON DRIVE



All these Universal diagrams have an initial force of zero (a), a sinusoidal increase to maximum (b) and a final value of zero (d).

Type I has the lowest maximum value and a somewhat gradual change to maximum deceleration (c). Its indexing action is smooth and ideally suited for light duty, high speed applications.

Type II maintains relatively low maximum values (b & c) and has an extremely smooth transition from acceleration to deceleration. It is recommended for high inertia, slow speed applications and where cam input torques must be limited.

Type III has the highest acceleration and deceleration values among the three due to the constant velocity period (e). It is used where a constant velocity is necessary or where low impact force, low centrifugal force or a drastically smaller cam is an attribute to the machine's function.

Versatility of the Universal Cam Theory enables Ferguson to design cams of any configuration calculated to enhance the operation of a machine employing intermittent motion.

Designs of other indexing devices, such as geneva drives and ratchets and cranks, do not permit the utilization of different acceleration characteristics. Their vibrations are severe and operating speeds are limited by poor dynamic conditions and backlash. In the case of a geneva drive the value of certain points in the diagram may vary according to the number of stops the drive provides. However, the initial force is always a significant factor, the rise and fall is sharp and the return to zero is abrupt.

Curves of the geneva, ratchet and crank and Ferguson Drive (Type I) show **why the Ferguson Drive does what no other drive can do . . . and why Ferguson Machine Corporation is the leading designer and manufacturer of cams and cam indexing mechanisms.**

FIG. 2

dotted line — 6-stop geneva drive
solid line — Ferguson Drive, Type I (modified trapezoid)
broken line — ratchet & crank (modified cosine)

Only the Ferguson Drive has initial and final forces of zero combined with low maximum values and a gradual change. The geneva and crank devices' inherent characteristics are dynamically poor and restrict their usefulness for modern production requirements.

Get more information on high speed, precision indexing. **SEND FOR CATALOG NO. 160.** It's the most comprehensive catalog of intermittent motion equipment ever published, containing complete application data on index mechanisms and tables, in-line machines, dial feeds and other standard components and machines. Be sure you have a copy. Write

Ferguson Machine Corporation
7818 Maplewood Industrial Court
St. Louis 17, Missouri

. . . continued

between charging and battery voltages. Carbon contacts make and break in advance of main contact operation. Safety Electrical Equipment Corp, 1187 Dixwell Ave, New Haven, Conn.

Circle 312 on Reader Service Card

10-durometer silicone rubber

has exhibited good resistance to compression set and endurance in high-temperature, oven-aging tests. Available in sheets to 14 x 21 in., in thicknesses 3/32 through ¼ in. Can be supplied molded or die-cut to size. Edenville Plastics Inc, Mountainside Rd, Warwick 2, NY.

Circle 313 on Reader Service Card

Size-11 synchronous motor . . .

provides synchronous speed of 8000 rpm and pull-out torque of 0.48 in.-oz. Available with plain or pinion shaft. Operates on 26 v, 400 cps. Power requirement is 3.4 w. Kearfott Div, General Precision Inc, 1150 McBride Ave, Little Falls, NJ.

Circle 314 on Reader Service Card

Constant-duty timer switch . . .

has forced-advance drive. Surplus torque permits addition of actuating devices directly to drive shaft, often eliminating need for secondary electrical controls, such as solenoids and relays. Intelligence drum can be provided on drive shaft to indicate cycle position continuously. Standard circuit rating is 115 v, 15 amp. Cam controls available for up to 24 circuits. Isolated circuits can be 250 v, 25 amp. Electronic Timers Co, Warsaw, NY.

Circle 315 on Reader Service Card

Rack-and-pinion control . . .

package combines four sealed ball joints, rack and pinion, and assembly hardware. Design is said to be flexible enough for use in light, steerable vehicles and equipment.

continued on page 70

The Human Eye, Nature's inspiration for the camera, can convert wavelengths of blue-green light measuring as little as 400 microns into visual perceptions that are truly life-size. Yet this entire human mechanism occupies space less than 1″ in diameter.

Tiny New Potentiometer, shown actual size, is designed to add space-saving precision to missile and aircraft servo mechanisms. Two MPB bearings in it assure accurate, low-torque shaft rotation — a vitally important benefit in sub-miniature components.

Man With Miracles. This is Maurice Hebert, one of MPB's Sales Engineers. He'll personally help you choose the correct MPB bearing to reduce friction and increase the precision of your instruments — while keeping your operating costs low with trouble-free service.

Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN POTENTIOMETER SHOWN ABOVE

The Smaller The Better is often completely true. Engineers now know that miniaturization is the surest method of developing new or improved components for many of the latest developments in modern industry. But, as components become smaller, the problems of maintaining high precision and long service life become larger — and the call for MPB bearings constantly increases. MPB answers with the most experienced engineers in the miniature bearing industry, and advanced research facilities . . . producing over 500 types and sizes of bearings from ⅜″ O.D. down, with specials as required. We welcome your request for engineering advice, our catalog, or both.

Write Miniature Precision Bearings, Inc., 203 Precision Park, Keene, N.H.

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Helps you perform miracles in miniaturization

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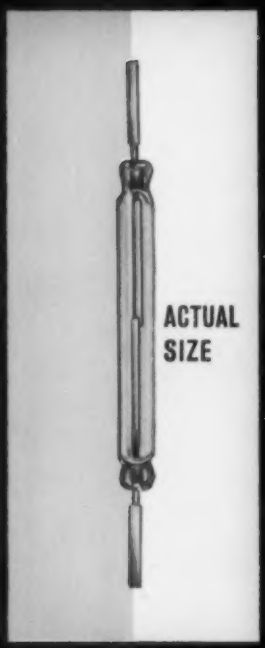
CIRCLE 68 ON READER SERVICE CARD→

NOW from C.P. Clare & Co....



Switch capsule of the new Clareed Sealed Contact Reed Relay consists of a pair of magnetically operated contacts, hermetically sealed in a glass capsule, in an atmosphere of inert gas.

SPECIFICATIONS

Contact Arrangement: Normally form A, form B, in combination form C

Overall length: 3-½ in. max.

Outside diameter: 0.215 in. max.

Contact material: Gold

Contact rating: 15 volt-amperes max., non-inductive: 1 amp. max.; 250 volts max.

Contact resistance: 25-40 milliohms.

Life expectancy: At 14 volt-amperes (½ ampere, 28 volts dc), 20,000,000 operations.
At 7 volt-amperes (¼ ampere, 28 volts dc), 100,000,000 operations.

Minimum breakdown voltage: (60 cps) 500 volts rms.

Insulation resistance: 500 k megohms min.

Low level load test: 8 microamps, 800 ohms, 250 millivolts, open circuit operated at 3 ips, 100 million operations with no failures.

Switches per Coil	Watts to Just Operate Typical Coils	Milliseconds (Including bounce) Operate Excess NI over P.U. 100	200	Release
1	0.25	1	0.8	0.25
2	0.30	1.5	0.9	0.25
3	0.35	2.2	1.5	0.25
4	0.42	3.2	2.2	0.25
5	0.52	3.5	2.5	0.25
6	0.8	5	3.5	0.50
12	1.5	6	5	0.50
20	3.5	8	6	0.50

CONTACT BOUNCE		
	At "just operate"	0.3 ms max.
	At 200 excess NI	0.5 ms max.
	At 400 excess NI	0.8 ms max.
	No bounce on release.	

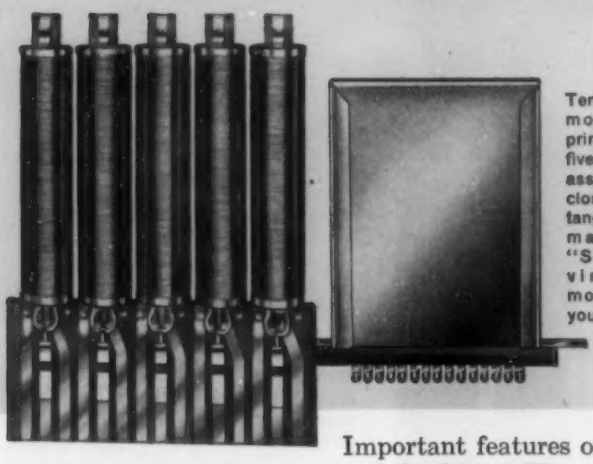
...CLAREED®

a New Concept in Relay Design

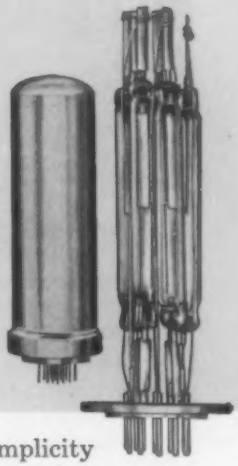
The new CLAREED Sealed Contact Reed Relay effectively eliminates contact contamination. With its contacts hermetically sealed in contaminant-free inert gas, this new design assures millions of perfect operations. Hundreds of millions are possible when operated at up to ½ rated contact load.

CLAREED relays are ideal components for transistor drive applications and for use in computers and data processing equipment. Their low inductance and the low inductance change in the operating coil at each operation limits the transients produced. Submit your packaging problem for recommendations.

• PACKAGED TO MEET *your* REQUIREMENTS



Ten CLAREED switches, mounted in line on a printed circuit board with five magnetic coils. This assembly can then be enclosed in the flat, rectangular container or it may be coated with "Skin-Pack," a tough vinyl plastic, and mounted directly into your equipment.



Six CLAREED switches clustered for mounting in a single tube container.

Important features of CLAREED relays are their simplicity and flexibility. They may be mounted to meet the requirements of almost any application and environmental condition, even on your own printed circuit board—to comply with your mechanical design configurations.

CLAREED relays are as flexible as your application requires. Consultation with your nearby CLARE sales engineer is invited. Additional information may be obtained from C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, Box 134, Downsview, Ontario. Cable Address: CLARELAY. *Send for Bulletin CPC 5.*

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BOOTH NOS. 2218 & 2220

CLARE FIRST in the industrial field

One word explains the popularity of these switches...

Dependability!

Denison LOXSWITCH Limit Switches operate with the dependability of Old Faithful. Oil- and dust-tight features, superior electrical characteristics and mechanical design result in three to five times longer life than comparable switches.

L100W HEAVY DUTY LIMIT SWITCH

- 45 CIRCUIT ARRANGEMENTS.
- LONGEST CONTACT LIFE due to lowest impact of 2.5 grams and minimum "bounce".
- WATER-, DUST- AND OIL-TIGHT, NEMA 12.
- ONLY FOUR MOVING PARTS. Longer life, easier to maintain.
- 70° SAFETY OVERTRAVEL without use of extra springs or cams.
- OVER 150 LEVER STYLES.

MODEL M PRECISION LIMIT SWITCH

- LONG MECHANICAL LIFE nylon latch mechanism.
- 600 VOLT INDUSTRIAL CONTROL RATING.
- COMPLETELY ISOLATED CIRCUITS.
- 6° TRIP DIFFERENTIAL, 50° overtravel in both directions.
- PRECISION REPEATABILITY ± .001".
- WATER-, OIL-, DUST-TIGHT – NEMA 12.
- FULLY INTERCHANGEABLE with thousands of existing layouts.

BOTH MODELS AVAILABLE WITH PLUG-IN CONVENIENCE

Write for literature describing our complete line.

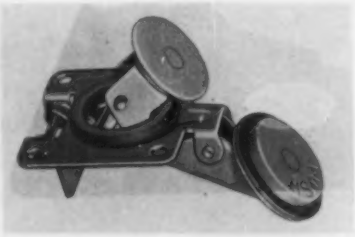
Address R. B. DENISON MFG. CO., 386 Broadway, Bedford, Ohio

DENISON LOXSWITCH

*Wire with **LOXSWITCH** and you wire for good!*

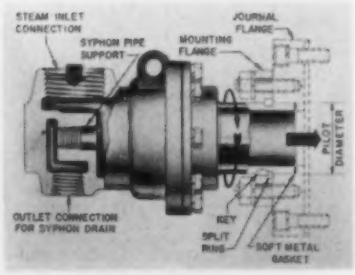
Various linkages are available. Steering or control column is secured to pinion by lock pin supplied with assembly. Reported to be more reliable and longer lasting than clevis-and-pin arrangements or bent-rod, cotter-key methods. OEM production price, $4.50 each. **Superior Ball Joint Corp, 9058 Trier Rd, Fort Wayne, Ind.**

Circle 316 on Reader Service Card



Electronic flush-type latches . . . for black boxes are said to open quickly and to provide tight sealing against elements. Gives secure over-center locking. Close button can be used as handle when latch is open. In arctic weather, large-size pushbutton is easily worked with arctic gloves, and open latches are not easily overlooked. **US Chemical Milling Corp, 1700 Rosecrans Ave, Manhattan Beach, Calif.**

Circle 317 on Reader Service Card



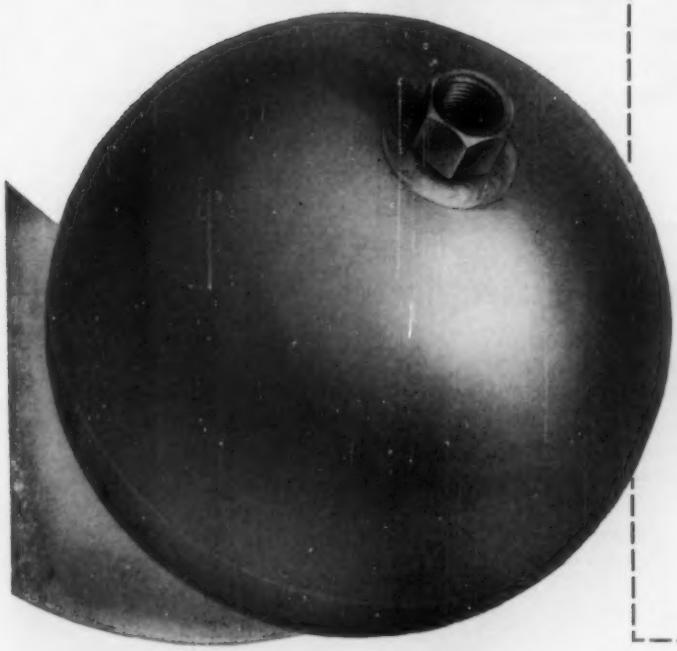
Flanged rotary joints . . . are equipped with machined straight-rotating sleeves, in which outside pilot diameter is held to close tolerances. Attachment of joint to rotating drum, dryer or roll is by means of mounting flange keyed to rotating sleeve and drawn up against spacing ring. Available in 2-, 2½- and 3-in. sizes, suitable for up to 200-psi saturated steam or 400-psi cold-working pressure. Also, hot oil, under 100 psi, can be handled up to 500 F. **Barco Mfg Co, Dept J-21, 500 Hough St, Barrington, Ill.**

Circle 318 on Reader Service Card

Miniature toggle switch . . . is rated conservatively at 28 v dc, 1 amp, resistive. Available with SPDT or DPDT circuit arrangement. Can be supplied with

continued on page 72

need floats?



Name the way you want them!

MATERIAL_____

SHAPE_____

SIZE_____

PRESSURE_____

QUANTITY_____

MORE INFO_____

*Your Name*_____

*Title*_____

*Company*_____

*Address*_____

_____

See below for details

Fill in blanks, tear out, and mail to:

W. H. NICHOLSON and COMPANY
Wilkes-Barre, Pa.

Nicholson can deliver precision welded floats —made to your specifications—to fit your production schedule. Use the above form to tell us how you want them.

Here are the standard specs:

- **MATERIAL**—steel floats with chromium, cadmium or copper plating—with sandblast or pickled finish . . . stainless steel and Monel floats—rough-buffed, polished or with welds ground smooth and highly finished.
- **SHAPE**—spherical, elliptical, cylindrical.
- **SIZE**—from 2 inches to 14 inches diameter.
- **PRESSURE**—from vacuum to 4800 lbs.
- **QUANTITY**—as many as you need.

These high tensile strength floats have exceptional resistance to pressure and corrosion. Float halves are die-formed, with inward rolled edges—not spun, laminated or electrodeposited.

Today, thousands of Nicholson floats are in service—most as buoyancy mediums . . . many as fluid chambers and pressure vessels. Write for details about the full Nicholson line.

W. H. NICHOLSON AND COMPANY, 12 OREGON ST., WILKES-BARRE, PA., *Sales and Engineering offices in 98 principal cities.*

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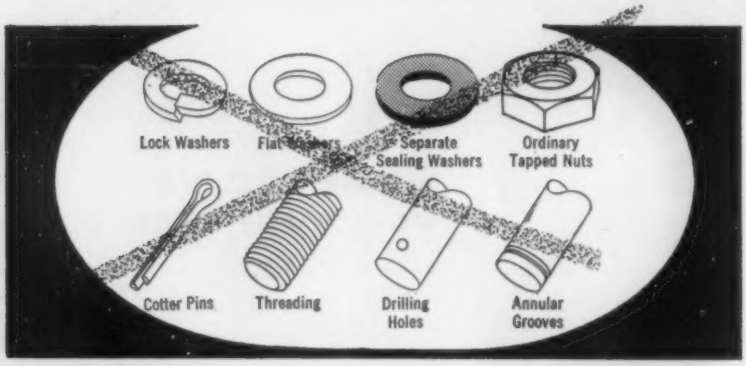
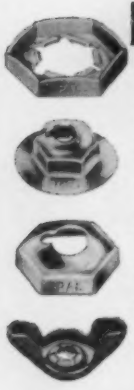
of Wilkes-Barre

PALNUT® LOCK NUTS and FASTENERS *Eliminate*

one or more of these assembly parts or operations



–and provide compact, vibration-proof assemblies



PALNUT Lock Nuts for Threaded members

Spring tempered steel Palnuts, with the dependable double-locking thread form, are available in many stock types and sizes to meet practically any assembly need. Here are typical advantages:

- **Low cost**—less than other locking devices, often less than plain nuts.
- **Easy, fast assembly** with ordinary manual or power tools, extra fast with Palnut Magnetic Wrenches.
- **Save Parts.** One Palnut replaces 2, 3, even 4 parts according to application.
- **Save Space** by eliminating auxiliary parts.
- **Save Weight**—up to 85% reductions in fastener weight.
- **May be removed and re-used.**

FASTENERS for Unthreaded Studs, Rods, Pins, etc.

SELF-THREADING NUTS

Save threading costs. Form their own deep, clean threads while tightening on studs of any malleable material, including aluminum or zinc die-cast; also rods, shafts, wire or pins of steel, aluminum, brass or plastic. Fast assembly with standard tools. Vibration-proof grip, whether seated or unseated. Remove and reuse on same studs. Sizes for #6, #8, #10, 1/4" and 1/4" dia. Write for Bulletin 585-A.

PUSHNUT® FASTENERS

Simply push on unthreaded studs, rod, wire or rivets. Strong spring grip resists removal. Save threading, grooving, drilling for cotter pins. Low in cost, fast assembly. Many types and sizes.

Write for literature and free samples, stating type, size and application.

THE PALNUT COMPANY
Division of UNITED-CARR Fastener Corp.
65 Glen Road, Mountainside, N. J.
Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

PALNUT® LOCK NUTS and FASTENERS

Quick, secure fastening at low cost

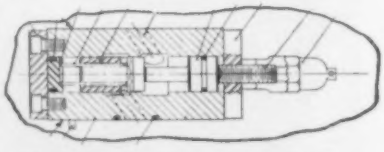
maintained or maintained-momentary action of batt handle. Withstands 50-g min shock and conforms to vibration and dielectric requirements of MIL-6745. Behind-panel mounting length is 45/64 in. max. **Control Switch Div, Controls Co of American, 4220 W Lake St, Chicago 24.**

Circle 319 on Reader Service Card

2-position slide table . . .

for varied metalworking operations is powered by 3-in.-bore air cylinder or 2-in.-bore hydraulic cylinder. Stroke length is infinitely adjustable from 1 to 15 in. by means of hydraulic cushions and stops. Working surface of top slide member measures 30 x 12 in., and has two longitudinal, ¾-in.-bolt T-slots, spaced 6 in. apart. Slide assembly base measures 34½ x 16¾ in. **Russell T Gilman Inc, 623 Beech St, Grafton, Wis.**

Circle 320 on Reader Service Card



Pipeless flow-control valve . . .

is noncompensated ¾-in. dual unit that provides separate, adjustable metering of fluid in each of two cylinder lines. Installed between ½-, ¾- or 1-in. solenoid-controlled, pilot-operated valve and subplate. **Double A Products Co, Sub of Brown & Sharpe Co, Manchester, Mich.**

Circle 321 on Reader Service Card

Thermistor sealed in glass rod

is adaptable to temperature measurement, control and compensation. Said to make possible timing periods in electronic, R-C timing circuits that are independent of changes in ambient temperature. Cold resistance at 77 F is 100 ohm; this drops to about 25 ohm at 122 F. Time constant is 25 sec when suspended by lead in still air at 77 F. Available from stock. Delivery, about 3 wk. Price, $5.20 per unit. **Victory Engineering Corp, 546 Springfield Rd, Union, NJ.**

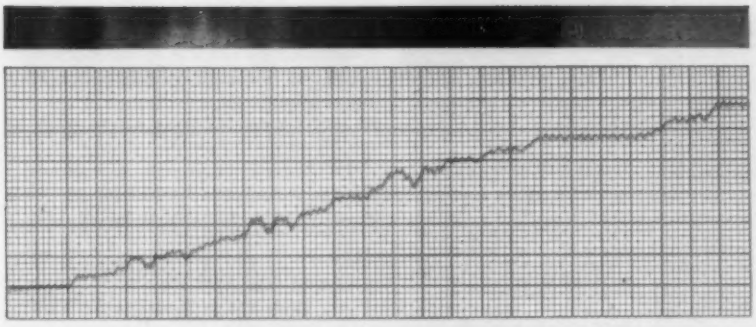
Circle 322 on Reader Service Card

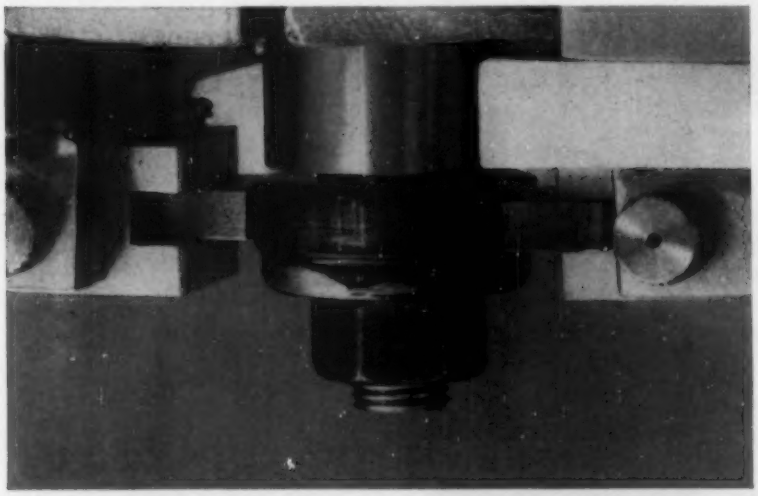
10%-efficiency solar cells . . .

are offered in production quantities. Also available for the first time are shingled solar-cell assemblies with 10% min conversion efficiencies. High-efficiency cells measure 0.4 x 0.8 in., have spectral response of 4000 to 11,500 angstroms and operating temperature range of –85 to 347 F. Price of 10%-efficiency cell is $8.25

continued on page 74

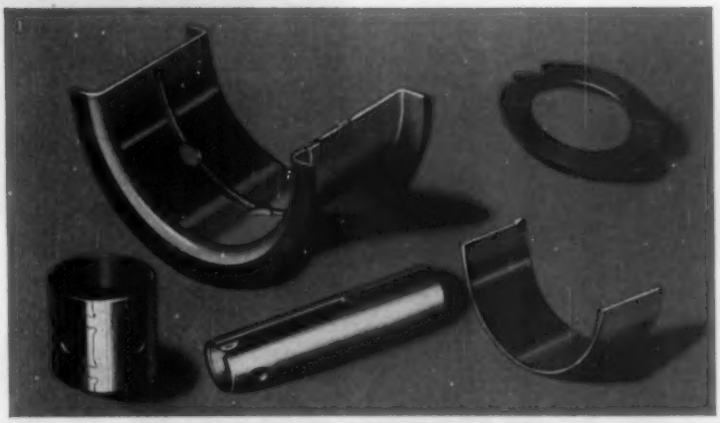
WE TAKE THE PULSE OF BEARINGS ON TAPE TO MAKE THEM EVEN BETTER!





TO TAPE-RECORD THE "HEARTBEAT" OF BEARING METALS UNDER LOAD, WE USE THIS SPECIAL FRICTION AND WEAR TESTER. (left) The result is highly accurate data on the behavior of bearing-metal surfaces, invaluable in our fundamental research into friction. By means of this instrument, we're able to correlate, more closely than ever before, specific alloy compositions with their degree of the "stick-slip" phenomenon (in which one surface sliding over another slides . . . stops . . . slides . . . stops . . . and so on) which accompanies unlubricated sliding action. We can also determine accurately the compatibility of bearing materials with shaft metals in lubricated systems . . . showing us which metal or alloy is most likely to be superior for a given bearing application. In short, this Friction Tester is a fundamental research tool which gives us positive answers to difficult bearing problems, faster than ever before.

ONE REASON WHY F-M SLEEVE BEARINGS and other F-M products give you the finest possible performance — this and the other unusual precision equipment used by Federal-Mogul research. You'll find F-M sleeve bearings used in turbines, engines, and countless other types of power transmission equipment . . . F-M precision thrust washers in pumps, automotive engines and transmissions, motors . . . F-M formed bushings in refrigeration compressors, electric motors . . . and low-cost F-M spacers in motor mounts, machinery, control mechanisms. These are just a few examples.



There's much valuable data in our Design Guides on sleeve bearings, thrust washers, and bushings; and in our brochure on spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings
bushings-spacers
thrust washers

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.

FAIRFIELD FACILITIES . . . at Your Service

Left—High accuracy balancing of rotating parts, including unusual off-center and counterweighted designs, can be handled rapidly and efficiently with the aid of this ingenious machine which utilizes stroboscopic light to locate the unbalance, an electric meter to measure the amount of unbalance, and a drill, mounted integrally, to remove indicated amount of metal for desired balance—followed by immediate inspection—all completed in a single handling.

Below—Other examples of specialized equipment "at your service" at FAIRFIELD.

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Gear Tooth Honing . . .

Bolt Hole Honing . . .

—to give you

1. TIME SAVINGS
2. LOWER COSTS
3. BETTER GEARS

At Fairfield, YOUR GEARS are in the hands of specialists equipped with every facility for handling production RAPIDLY, EFFICIENTLY, and ECONOMICALLY. Special or unusual requirements in design, size, finish, tolerances, processing, materials, and heat treating are often "standard" at FAIRFIELD.

Fairfield's gearmaking facilities save capital investment for many builders, large and small, of power driven equipment. At Fairfield, you get the benefits of high production rates and big volume output in an ultra-modern plant designed exclusively for producing fine gears. *Become a Fairfield customer; it pays!* CALL OR WRITE.

FAIRFIELD
MANUFACTURING COMPANY, INC.
2305 S. Concord Rd. Lafayette, Indiana
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Gears and Differentials For FINE GEARS *Made to Order for:*

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
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. . . continued

in quantities of 100 to 999. In shingled assemblies, cells are $6.75 each in quantities of 100 to 999. Hoffman Electronics Corp, 3761 S Hill St, Los Angeles 7.

Circle 323 on Reader Service Card

Silver-zinc power pack . . .

is automatically activated in fraction of a second, yet is suitable for delayed use. In typical application, 28-v battery is operated at 15 amp, delivering 420 w for 19 min. Operating temperature range is 32 to 160 F. Consists of 19 cells of 3 amp-hr nominal capacity and has volume of 214 cu in. Weighs 11.4 lb, including case, heaters, activation mechanism and other hardware. Yardney Electric Corp, 40-50 Leonard St, New York 13.

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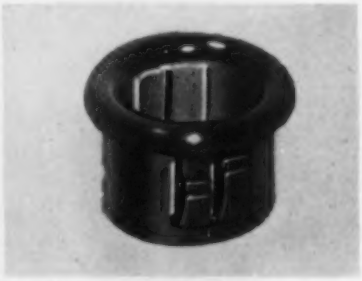


Nylon snap bushings . . .

for mounting holes varying from $\frac{3}{8}$ to $1\frac{1}{2}$ in. dia, fit into all panel thicknesses up to $\frac{1}{4}$ in. Stocked in black, with other colors available on special order. Install in mounting holes under finger pressure, yet withstand 35-lb push-back test min. Bushings are removed by compressing locking steps. UL and CSA approved. Withstand operating temperatures in excess of 302 F. Free samples are offered. Heyman Mfg Co, Kenilworth, NJ.

Circle 325 on Reader Service Card

Machinery-shim process . . .

produces any size shim, from smallest to 12 x 12 in., at die cost of about $20 to $40, depending upon detail involved. Shims can be made from brass, steel, stainless steel, bronze and any other sheet alloy. Process particularly suited to thin shims—0.001 to 0.010 in. thick. Dayton Rogers Mfg Co, 2824 13th Ave S, Minneapolis 7.

Circle 326 on Reader Service Card

Light-medium-duty casters . . .

include eight caster types. Have uniformly designed top plates, protective bearing dust caps and double-ball race construction. Top plates can be fitted to bolt hole

continued on page 76

3M COMPANY CHEMICALS THE RAW MATERIALS OF PROGRESS

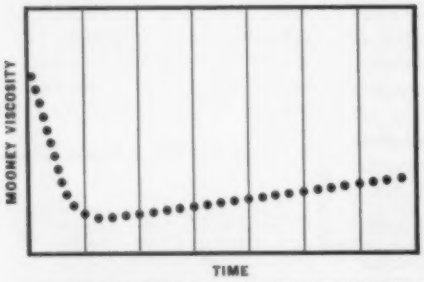
NEW FLUOREL® 2141

BRAND ELASTOMER

Its Mooney Scorch Rating is ideal for the fluorinated rubber processor because it makes possible fast, more economical cures with fewer defects, less scrap, fewer rejected parts. Material can be reprocessed with greater safety.

A SIGNIFICANT BREAKTHROUGH in elastomer processing has been made possible by 3M research through development of its new FLUOREL 2141 Elastomer.

This remarkable new product has a Mooney Scorch Rating



MOONEY SCORCH CURVE for FLUOREL 2141 Brand Elastomer.

outstanding among fluorinated elastomers. The range permits the rubber processor to achieve fast, more economical cures with fewer defects, less scrap and fewer rejected parts. The inherent safety of FLUOREL Elastomer 2141 allows repeated reprocessing to produce high quality parts that meet military specifications or other critical end uses.

At the same time, the outstanding physical qualities of the elastomer are retained. They include: non-combustibility, excellent resistance to corrosive chemicals, fuels, solvents and ozone, minimum compression set, rated for continuous service at 400° F., and the ability to tolerate 600° F. temperatures for reduced periods under certain service conditions.

If you use or work with elastomeric materials, it will pay you to examine the remarkable features of this new product. Examine, too, your present rubber products with an eye toward increasing their life and quality through use of FLUOREL 2141 Elastomer. For complete data, write today on your company letterhead to: 3M Chemical Division, Dept. KAS-30, St. Paul 6, Minnesota.

FLUOREL 2141 "O" ring, bottom. Note freedom from defects because of the improved scorch characteristics of FLUOREL Elastomer "O" ring as opposed to elastomer at top of photograph.

"FLUOREL" is a reg. T.M. of 3M Co.

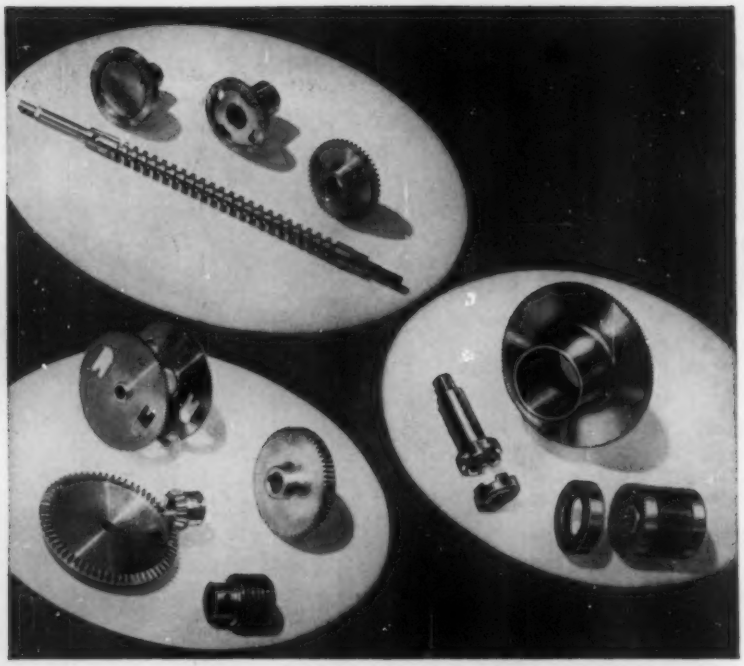
CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

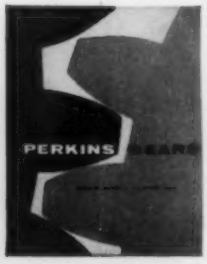
3M COMPANY

CIRCLE 75 ON READER SERVICE CARD



small and fine pitch gears for precision equipment

No matter how fine your gear requirements — Perkins can solve your problems. Perkins unique custom-gear engineering service, available to your engineering staff prior to the blueprint stage, will . . . eliminate production headaches . . . cut excessive costs. This service — recognized by leaders in the radar, electronic and missile fields, and backed by 52 years of custom gear experience — assures the precision quality needed to guarantee trouble-free operation. Don't gamble with gear performance . . . Perkins skilled personnel, together with modern up-to-date equipment guarantees fast delivery on prototypes or production runs. Call or write Perkins for complete information on custom-gear engineering and a quotation on your requirements. Then judge for yourself.



YOURS ON REQUEST
Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

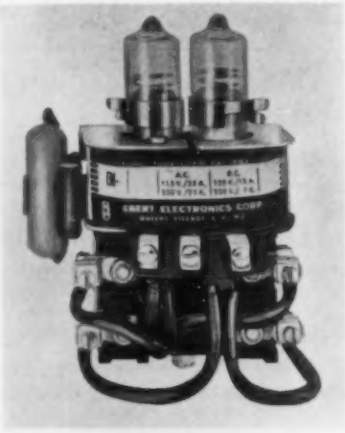
Dept. 72 West Springfield, Mass.
Telephone: REpublic 7-4751

spaces of 1¾ to 3 in. Fork-angle design permits use of 2½-, 3½- or 5-in. wheels. Made of heavy steel throughout, caster forks are machined from 12-gage steel with top plates of 7-gage steel. **Colson Corp, 7 S Dearborn St, Chicago.**

Circle 327 on Reader Service Card

Multiposition swivel lock . . . allows fingertip conversion of casters from swivel to rigid at any position. Any number of locking slots can be milled into caster-yoke base at specified positions to provide controlled movement in any direction. Spring-loaded, finger-operated plunger, on underside of attaching plate, engages slots. Lock can be used alone to facilitate steering over prolonged straight course, or in conjunction with wheel brake. Offered as optional accessory on company's line of heavy-duty, and extra-heavy-duty, forged-steel casters having capacities up to 3000 lb. **Hamilton Caster & Mfg Co, 1633 Dixie Highway, Hamilton, Ohio.**

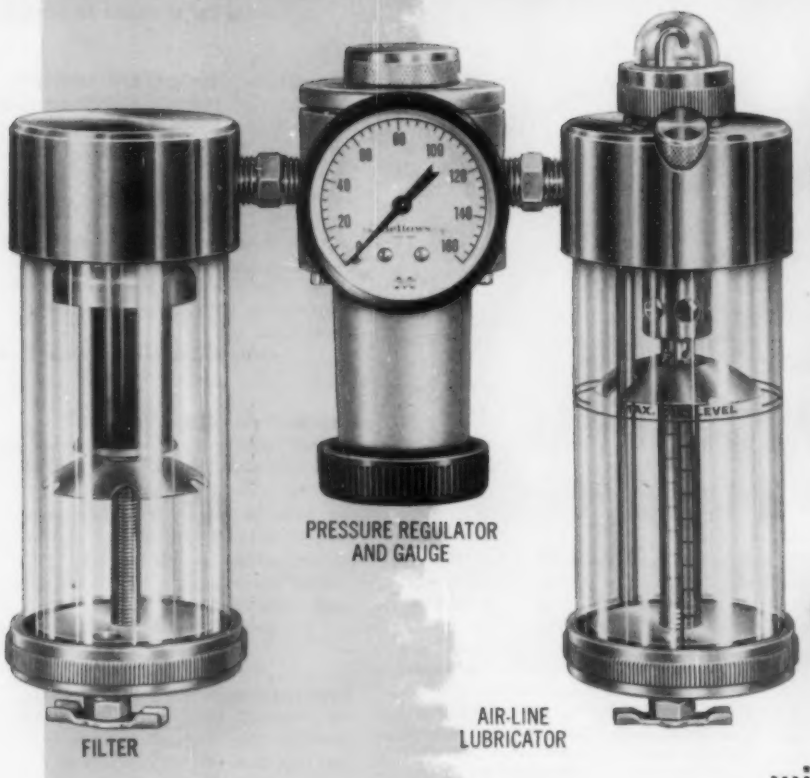
Circle 328 on Reader Service Card



Sensitive power relay . . . allows extremely low currents through actuating coil, preventing damage to delicate instrument-control contacts. Unit, which employs energizing coil in resonant circuit, is operated by 0.019 amp through

continued on page 78

AIR-POWERED EQUIPMENT



PERFORMS MORE EFFICIENTLY

COSTS LESS TO MAINTAIN

GIVES LONGER SERVICE LIFE

with a

Bellows LUBRI-AIR® CONTROL UNIT

HERE'S WHY: Once adjusted to the requirements of a particular air system, the Bellows Lubri-Air Control Unit automatically filters harmful dirt and moisture out of the air stream (40 micron filter element standard; 5, 10 and 20 micron units available) . . . automatically regulates air pressure by compensating for fluctuations in air supply and variation in cfm requirements of pneumatic equipment . . . automatically lubricates air-operated equipment by providing the correct amount of misted oil to the air stream. Bellows Lubri-Air Control Units are available in ¼", ⅜", ½", ¾" and 1" sizes.

Free Bulletin LA-15 gives complete information. Write for your copy today. Address Dept. PE-360. The Bellows Co., Akron 9, Ohio.

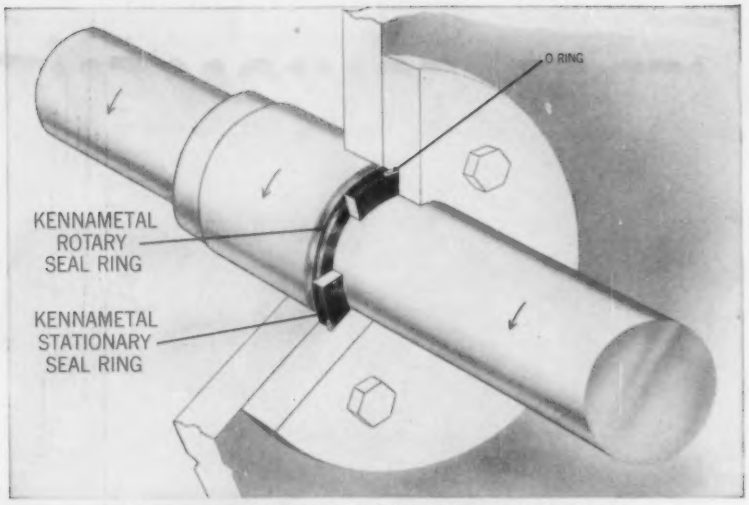
OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, O., V. D. Anderson Co., Cleveland, Ohio.

673-C

The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

AKRON 9, OHIO



Cross section view of typical unbalanced mechanical face seal utilizing Kennametal cemented carbides as seal ring material.

USE KENNAMETAL* ...and seal it for certain

When even a *little* leakage matters a lot . . . Kennametal Seal Rings can effect a substantially leakproof seal with a minimum of lubrication. The following characteristics of Kennametal hard carbides may be the key to *your* gas and liquid sealing problems.

Exceptionally good dimensional stability—Kennametal Seal Rings have no phase change upon heating and cooling because Kennametal has a more homogeneous structure than other commonly used materials. Kennametal Seal Rings can be lapped to a flatness less than half a light band, with a surface finish better than one-half microinch. Because of good dimensional stability, Kennametal Rings *retain* their flatness over an almost unlimited range of operating conditions.

Successful mating with rings of other materials—When used against opposing faces of graphite or carbon, Kennametal Seal Rings have been found to greatly lengthen the life of the seal. High resistance to abrasion and erosion prevent smearing or grooving out of the seal face.

Strength without great mass—The high rigidity of Kennametal materials permits more compact seal designs. A YME of up to 94-million psi (compared to steel's 30-million) permits use of smaller width/smaller thickness rings.

Corrosion/Wear resistance—Special Kennametal grades are available for applications involving mild to severe corrosion in combination with abrasion.

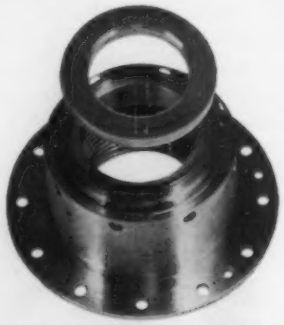
High temperature applications—Kentanium,† a hard titanium carbide alloy, retains all of the foregoing advantages at higher temperature ranges.

Kennametal Seal Rings have been used successfully for all the following: gases, exotic fuels, Lox, Freon, fluids, slurries, acids, basic solutions, synthetic and petroleum base fuels, organic solvents, butyl extracts. Chances are we can help *you* with your sealing problem.

Kennametal Seal Rings are available in complete seals from leading seal manufacturers. For more information, send for these booklets: B111A—"Characteristics of Kennametal," B444A—"Kentanium." KENNAMETAL INC., Latrobe, Pennsylvania.

*Trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

†Trademark 97289



Balanced seal for high speed/high temperature application, utilizing a Kennametal stationary ring and Kentanium rotating ring.

KENNAMETAL Inc.
LATROBE, PENNSYLVANIA

external contact. Has liquid mercury-to-mercury contacts. Ebert Electronics Corp, 212-26 Jamaica Ave, Queens Village 28, NY.

Circle 329 on Reader Service Card

Linear-motion potentiometers

are used with hydraulic and electrical actuators to measure linear displacement in ambient temperatures to 500 F. Meet or exceed applicable military specifications. Measure ½ in. dia. Said to have linearities to 0.05%. Potentiometers are end-actuated, with various shaft coupling configurations. Available with standard strokes of 1 to 5 in., in 1-in. increments. Edcliff Instruments, 1711 S Mountain Ave, Monrovia, Calif.

Circle 330 on Reader Service Card

Square developing tube . . .

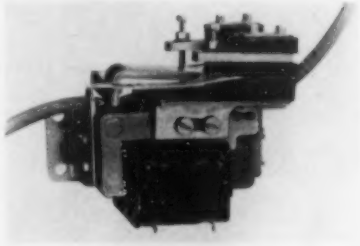
is used with white printer, which weighs 30 lb. Can be wall-mounted or placed on desk or table. Tube measures 30 x 4 in. on each side of square and is made of transparent polyvinyl chloride to permit viewing of developing process. White printer retails for $199. Grico Inc, Cuyahoga Falls, Ohio.

Circle 331 on Reader Service Card

Pressure-sensitive materials . . .

for drafting applications include tapes, templets, grid sheets, die-cut symbols and numbers and letters. Printed on shrink-resistant transparent materials. Templets, symbols, letters and numerals are packaged as individually slit strips. Applied Graphics Corp, Glenwood Landing, NY.

Circle 332 on Reader Service Card

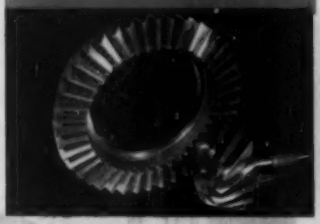


Electromagnetic valve . . .

provides electrical remote control of liquids and gases at vacuum of approximately 10 psi or 4 in. mercury. Clamp on rubber tubing controls flow. Valve is normally closed, and opens when coil is energized. Utilizes up to ¼-in.-ID rubber tube. Exerts ¼-lb force. Operates on 2 to 5 v ac or dc; consumes about 6 w. Available unmounted, or mounted on 4 x 6-in. bakelite baseboard with dust cover. Suitable for laboratory work, chemical proc-

continued on page 81

PLANOID® GEARS are low-ratio gears competitive with bevel and hypoid gears in efficiency and performance, but are manufactured at lower cost.

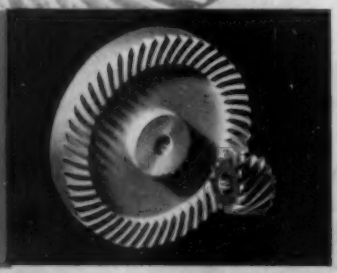


From Illinois Tool Works' unique family of gears . . .

SPIROID® GEARS

new gear economies
with new gear efficiencies

HELICON® GEARS bring even greater production economy to high quantity applications than is possible with face, bevel or worm gears.



Shown here are typical examples of outstanding developments in right-angle gearing introduced by Illinois Tool Works. Pictured above is a Spiroid gear, the first major advancement in gearing in thirty years.

Spiroid® Gears do the same job as worm gears with this notable exception: they do it more economically and more efficiently in less space. They are recommended for application in the field of medium to high-ratio right-angle gearing. For maximum economy they may be sintered, molded or cast in metal or plastic; however, even hardened steel Spiroid gears for maximum power transmission are manufactured more cheaply than worm gears.

SEND TODAY FOR THESE NEW GEAR BOOKLETS Free booklets are available giving complete information on the design, manufacture, applications and advantages of each of these gears. Request your copies today.

Spiroid® gears

SPIROID DIVISION OF ILLINOIS TOOL WORKS

2501 North Keeler Avenue, Chicago 39, Illinois

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choose from
Atlantic India's

thousands of rubber molds and dies

A 40 year accumulation of molds and dies are now on hand at Atlantic India, ready to serve you. Chances are one of our standing molds or dies will fit your needs.

If it happens that your application calls for a unique rubber product we have years of "know-how" at your command. What ever your need, washers, gaskets, molded parts, extrusions, sheet or sponge rubber, Atlantic India is ready to serve you.

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West Babylon, L. I., N. Y.

CIRCLE 80 ON READER SERVICE CARD

CIRCLE 204 ON READER SERVICE CARD

essing, machine-tool-coolant and lubricating control. When combined with adjustable timer, it can measure off accurate amounts. Can also switch flow on and off at preset times. Now in production as standard unit. **Milo Mfg Co, 259 N Broad St, Elizabeth, NJ.**

Circle 333 on Reader Service Card

Lightweight sketching tissue

is primarily for idea sketches and quick roughs. Lightly tinted, yellow paper takes pencil, charcoal or crayon. Reproduces on standard diazo, blueprint and office-copy machines. Available in 50-yd rolls, 42 and 48 in. wide. **Keuffel & Esser Co, Adams and 3rd Sts, Hoboken, NJ.**

Circle 334 on Reader Service Card

Dust-free cabinet . . .

is illuminated work chamber, with double filtration for max air cleanliness, for use on standard workbenches. Self-contained cabinet provides high dust-arrestance for assembly, research and testing of ballbearings, optical components and other precision instruments. Self-charging, electrostatic filtration is said to have arrestance value of 95% on dust particles ranging from 0.08 to 80 microns dia. **Specialties Inc, Skunks Misery Rd, Syosset, NY.**

Circle 335 on Reader Service Card

"You need 20 drawings by tomorrow night, fine . . . anything else?"

This trademark on a gear is the GUARANTEE of a quality-conscious gear manufacturer.

CINCINNATI GEAR has kept in the forefront of technological progress in gear-making methods and equipment for over 50 years. The oldest "tool" in our ultra-modern shop is *pride in true craftsmanship!*

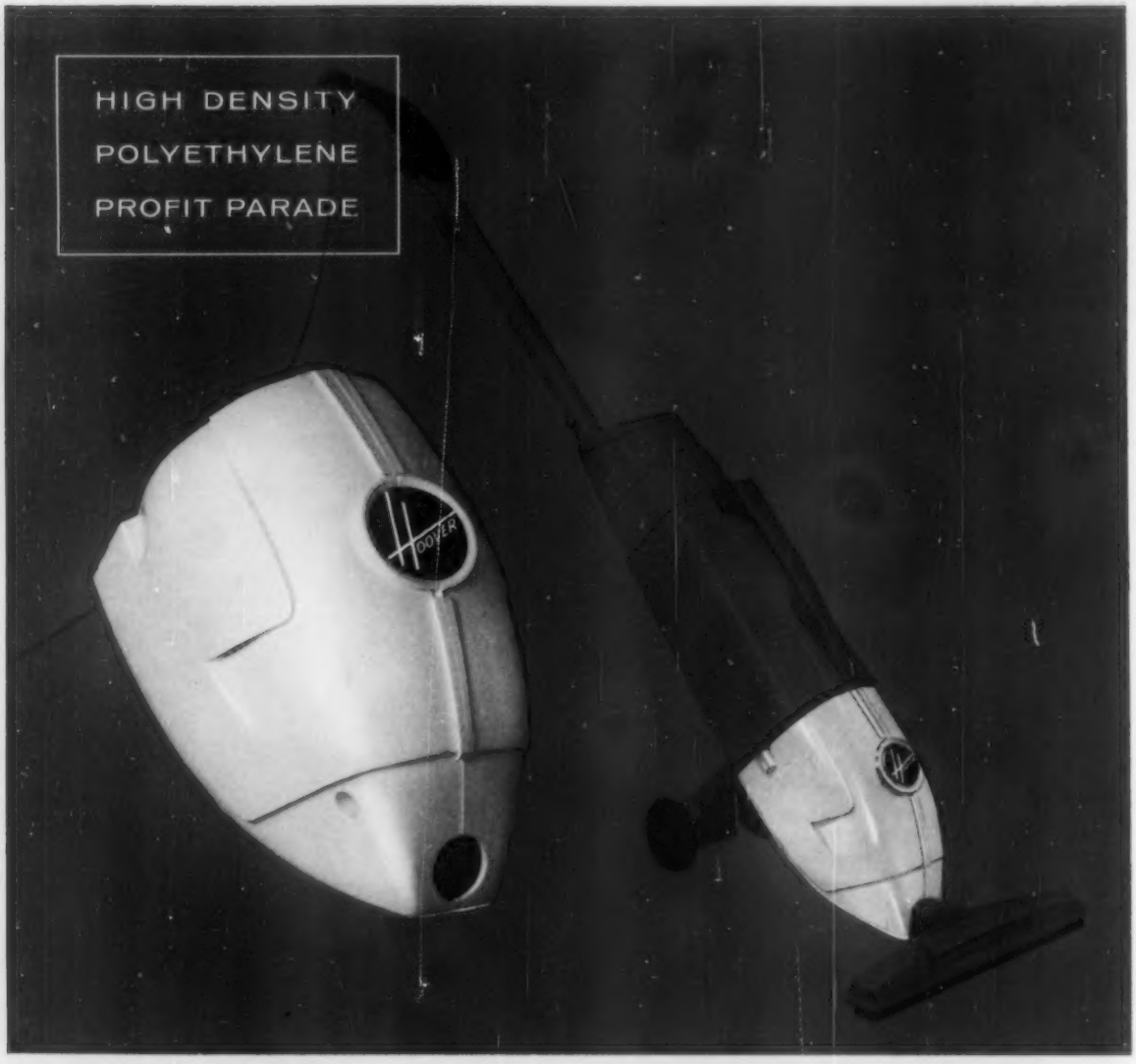
Send us your prints for quotation.

CINTI®

THE CINCINNATI GEAR CO.

Wooster Pike and Mariemont Ave. Cincinnati 27, Ohio
Custom Gear Makers Since 1907

GEARS, good gears only



Grace Plastic Goes into New Appliance Concept

Are you working on a "new concept" product? High density polyethylene from Grace could provide a better answer to your product's unique requirements than any other raw material. The Hoover Company reached just such a conclusion in screening plastics for the motor housing of their new home appliance concept—an electric floor washer that cleans with its own detergent solution and dries by vacuum action.

Why did Hoover select Grex high density polyethylene? The motor housing has to be unaffected by moisture and the chemicals with which it comes in contact. It must withstand heat generated by the motor and possess high impact strength. Its color—a primrose yellow—has to be an exact match of the other parts. Just as important, the housing must be light in weight, economical to produce and flame retardant.

By specifying Grex, Hoover obtained the motor housing they needed. Although the requirements for your new product may not be the same as Hoover's, bear in mind that this Grace plastic offers many remarkable properties still waiting to be exploited.

Find out more about high density polyethylene by calling in the experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION CLIFTON, NEW JERSEY

Hoover motor housing points up considerations in designing for Grex.

Designing superior parts with high density polyethylene requires knowledge of molding and mold design techniques and the inherent characteristics of the material. A few considerations that went into the motor housing of Hoover's new electric floor washer may be helpful in your own designing for Grex.

Color match. High density polyethylene flame retardant compounds, compared to natural high density polyethylene, are much more opaque white and therefore more difficult to color match. However, it is usually easier to obtain a color match with flame retardant Grex than with any other flame retardant plastic comparable in both cost and performance. In this case, a flame retardant compound was specified for the motor housing. The material was satisfactorily compounded to match a primrose yellow used for other parts of the appliance.

Section thickness. The original mold design for this housing incorporated heavy sections and variations in wall thickness which had to be corrected before actual production. These are to be avoided wherever possible as a cause of differential shrinkage or part distortion. As an added consideration, thinner wall sections result in economies in material and, with proper molding techniques, usually give a faster cycle.

Call us for help. If you are now working on a design for high density polyethylene—or are just thinking about some new project—remember that Grace is ready and willing to provide technical assistance. Bring us into your picture any time—the sooner the better.

Technical Service Department
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DESIGN LITERATURE

First into Outer Space

THEODORE J GORDON and JULIAN SCHEER. St Martin's Press, 175 5th Ave, New York 10. 5½ x 8¼, 197 pp. $3.95.

A popularized first-person story by Gordon, a Douglas Aircraft engineer who was test conductor for the three Air Force lunar-probe shots. Includes a 5-page glossary of "space terms" and some technical detail of engineering interest. Key statement: "A missile flight test seldom fails because of basic inadequacy of design; usually a two-bit part fails, a seemingly insignificant link in a basically strong chain." The juxtaposition of "two-bit" and the latin-based words at the end is obviously the work of ghost-writer Scheer, but the idea is good. —EJT

Introduction to Mathematical Thinking

FRIEDRICH WAISMANN. Harper & Bros, 49 E 33rd St, New York 16. 5¼ x 8, 260 pp. $1.40.

The author gives an insight into the nature of mathematical-concept formation, rather than a system of theorems and completely developed proofs. Examples and applications are pushed into the background in favor of a presentation of mathematical ideas. The book discusses in detail the structure of the realm of numbers.

Leibniz and Newton, proceeding from intuitive points of view, created differential and integral calculus. In the eighteenth century these investigations soared extraordinarily. This period of mathematics has been likened to the period of the great discoverers and the heroes of the sea. Mathematicians of that age stepped into a new intellectual world.

In odd contrast to this series of wonderful discoveries was the obscurity that spread over their foundations. Leibniz and Newton were not very clear about the meaning of a differential quotient. Their expositions vary, but on the whole they had a dim notion of calculating with infinitely small quantities. What this means is difficult to say; and so a certain obscurity has been connected with "infinitesimal calculus" since its birth.

Clear-thinkers, such as the philosopher Berkeley, were not sparing with their criticism. In the treatise "The Analyst" (1737) there is a detailed discussion of calculus, which makes it seem mysterious, almost mystical—an art more than a science. This view has even infiltrated into textbooks. For example, Lubsen, an author well known in the last century, states that differential calculus is a mystical method operating with infinitely small quantities; the differential is a breath, a nothing. Then follows an English quotation: an infinitesimal is the spirit of a departed quantity.

Topics covered include: the various types of numbers, theory of integers, principle of complete induction, operating with sequences, remarkable curves, theories on real numbers, ultra-real numbers, complex and hypercomplex numbers.

Interlingual Glossary of Nuclear Physics

BENE, BEELER and GOLUB. D Van Nostrand Co Inc, 120 Alexander St, Princeton, NJ. 5 x 7½, 214 pp. $6.

With the worldwide development of atomic energy, interlingual glossaries become a necessity; and this one, (full title: Glossaries Interpretum: Nuclear Physics and Atomic Energy) though expensive for its size, represents a good and valuable start. It gives French, German and Russian equivalents of more than 2100 English terms related to the nuclear field, giving abbreviations and symbols in some cases, but no definitions.

Aircraft Metals at Very Low Temperatures

McGEE, CAMPBELL, CARLSON, MANNING. Battelle Memorial Institute. (WADC Technical Report 58-386), PB 151459. Dept of Commerce, Office of Technical Services, Washington 25, DC. 8½ x 11, 57 pp. $1.75.

This report (full title: "Mechanical Properties of Certain Aircraft Structural Metals at Very Low Temperatures") provides data to aid selection of materials for applications down to —425 F. Materials tested were sheet stock of 17-7 PH and AM-350 stainless, and A110 AT, C110M and 6A1-4V titanium. Bar stock tested included 4340 and Tricent steel, 7079-T6 aluminum, and ZK60A-T5 magnesium. Test values are given for

continued on page 85

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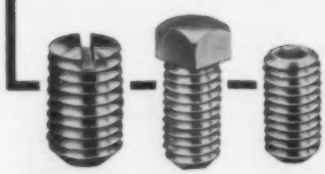

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A New Science Series

"The Neutron Story," DONALD J HUGHES. Doubleday & Co Inc, Garden City, NY. 4¼ x 7, 158 pp. 95¢.

"Magnets," FRANCIS BITTER. Doubleday & Co Inc, Garden City, NY. 4¼ x 7, 155 pp. 95¢.

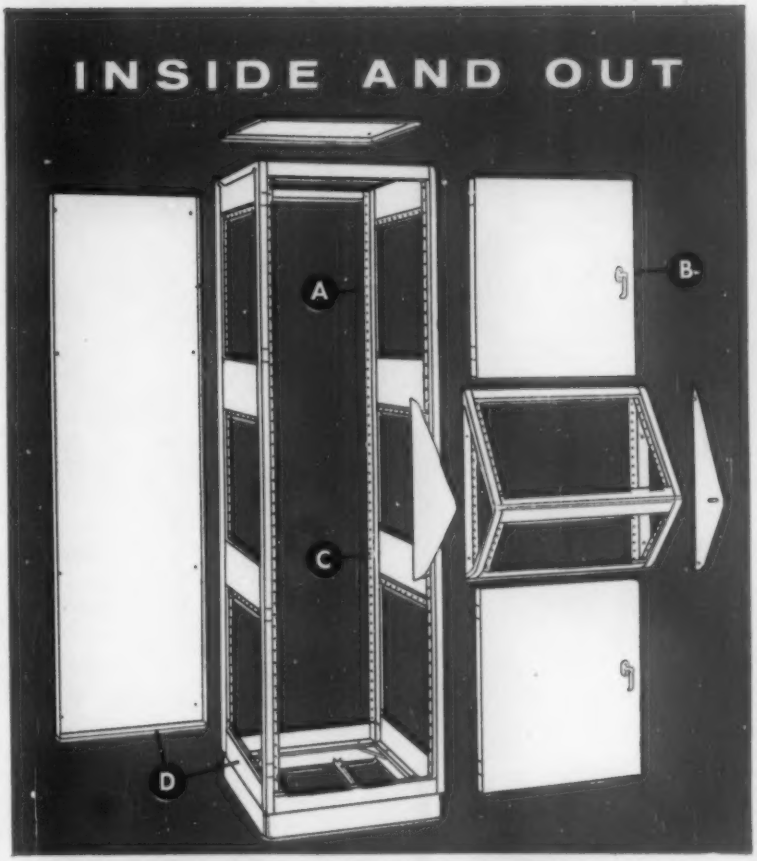
These are the first two of a planned series of paperbound publications to "offer students and the general public the writing of distinguished authors on the most stirring and fundamental topics of physics." They are written—quite definitely—for the younger set, with frequent use of such words as "stirring" and "fascinating." There are some color plates; but most illustrations are of the rough-sketch type. Most engineers, and most serious-minded future engineers, will find the books quite elementary, judging at least by the first of the series.

Mechanisms & Motion

K H HUNT. John Wiley & Sons Inc, 440 4th Ave, New York 16. 5½ x 9¼, 114 pp. $4.25.

This book perhaps could have been entitled "Kinematic of Mechanisms" for it does include topics usually found under this heading. But, in addition, it presents vector methods in deriving general equations of motion and in providing a foolproof rule for the direction and the sense of the Coriolis component of acceleration.

continued on page 56



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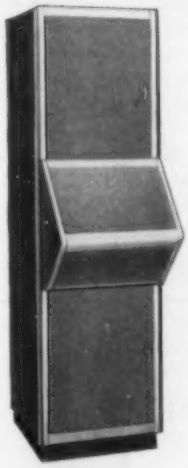

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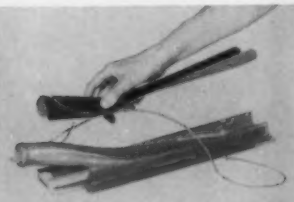

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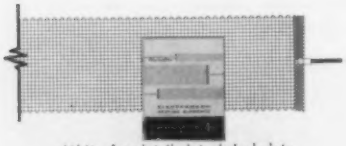

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One chapter also introduces space mechanisms. However, some readers may regret that a more direct attack has not been made on synthesis of mechanisms in these pages.

Topics covered are: vector methods in kinematics, general motion of rigid bodies, hinged-plane mechanisms, degrees of freedom of rigid bodies, plane mechanisms with sliding and higher pairs, and space mechanisms.

Arrangement of Groups of Men and Machines

THOMSON, COVNER, JACOBS and ORLANSKY. Dept of Commerce, Office of Technical Services, Washington 25, DC. 8 x 10¼, 127 pp. $2.25.

This is the most recent addition (published by Office of Naval Research) to the government-sponsored series on human engineering. It answers questions of how best to arrange space in small working areas and compartments and how to arrange major components (displays, controls, plotting boards, maintenance spaces) within the working compartments. Hundreds of dimensional sketches illustrate recommended layouts.

Operational Calculus

JAN MIKUSINSKI. Pergamon Press Inc, 122 E 55th St, NY 22. 7 x 10, 495 pp. $15.

Operational calculus had been known as early as the beginning of the nineteenth century, but its development and popularization was due to the later work of Heaviside, who applied it widely to problems in electricity.

The book is a methodical presentation of a theory published by the author in the years 1950-1957, together with applications. It is written

continued on page 88

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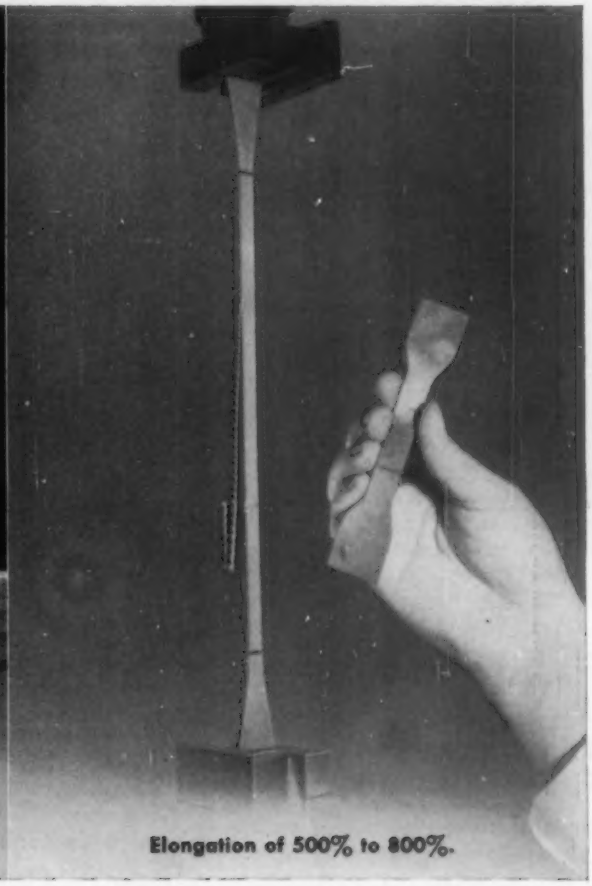

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to be of use both to an engineer, who regards the operational calculus merely as a tool in his work, and to the reader who is interested in proof of theorems and mathematical problems for their own sake.

Operators are introduced algebraically as a kind of fractions. They are a generalization of the concept of numbers: operations on them are performed in the same way as operations on numbers. This treatment may be simpler and more general than that presented in other books (which base their exposition on the Laplace transform) and can be understood by readers who are not acquainted with the theory of analytic functions.

Correction

The book "Modern Electronic Components" by G W A Dummer, Head of Components Research, Development and Testing at Royal Radar Establishment, Ministry of Supply, United Kingdom, was reviewed in the Feb 22 issue without an address from which it could be ordered. This publication is available from Philosophical Library, 15 East 40th St, New York 16.

ABSTRACTS FROM THE LITERATURE

Strength-rating Helical Gears

After discussing factors for rating strength of helical gear teeth as applied in the formula developed by American Gear Manufacturers Assn's Gear Rating Committee, a new approach is described. This combines different concepts of geometry factors, an improved evaluation of dynamic loads, rational allowable stresses, risk or reliability considered as a statistical probability. Effects of operating error and load-distributing tooth flexibility are also included.

"An Analysis of Factors Used for Strength-rating Helical Gears," E. J. Wellauer, Falk Corp; ASME paper 59-A-121. ASME, 29 W 39th St, New York 18.

Vacuum-pump Oils

Special oils of low vapor-pressure are employed to obtain the best results in the evacuation process. However, in such service the oil is exposed to contamination from air and other vapor media that the vacuum pump has to handle; these reduce the oil's sealing and lubricating effectiveness. Removing these contaminants through continuous conditioning of the oil not only improves its lubricating value, but also increases pumping speed and ultimate vacuum of the system.

"Conditioning of Vacuum-pump Oils," S. F. Bowser Co, Hamilton, Ontario, Canada; Lubrication Engineering, Dec '59, 5 No. Wabash Ave, Chicago 2.

Multivariable Experimentation

As an aid to studies of complex systems, a non-technical description is given of some of the statistical design techniques that have been developed during the last 15 years. Discusses selection of the variables in a given experiment, together with methods of determining the best experimental techniques. Bibliography included.

"Multivariable Experimentation," W. J. Youden, National Bureau of Standards; SAE Paper 116A. SAE, 485 Lexington Ave, New York 17.

How to Use the Library

Discusses five basic considerations that should help the engineer use the technical library with maximum efficiency: 1) function of the librarian; 2) uses of card catalogs; 3) indexes and abstracts; 4) bibliographies; 5) handbooks and manuals.

"Literature Engineering—or, The Why and How of the Engineer in the Library," Robert E. Runser, Technology Dept, Detroit Public Library; SAE paper 124B. SAE, 485 Lexington Ave, New York 17.

Abrasive Compounds

Discusses the two primary types of deburring compounds—those with and those without abrasive grains. It discusses the effects of particle size and tells how particles are reduced in size during barrel finishing. Also discusses uniformity of size and toughness of the grains, and relative advantages and disadvantages of various types of grain.

"Abrasive Compounds in Barrel Finishing," Arthur S. Kohler, Frederick Gumm Chemical Co, Kearny, NJ; Plating, Jan '60, 445 Broad St, Newark 2.

"Who's the wise guy who thought that up?"

Physiological Responses to Mental Tasks

This is a report of a study of the variations in several types of physiological responses to a systematic program of mental tasks of varying difficulty.

"Effects of Mental-task Difficulty on Physiological Response," Glassner and Peters, Engineering paper 848. Douglas Aircraft Co, El Segundo, Calif.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

ALUMINUM IMPACT EXTRUSION—Handbook, 34 pp. Updated guide to the impact-extrusion process, design characteristics, scope of design, and applications. Includes information on Alcoa facilities for processing, and property chart of alloys used in process. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.

Circle 340 on Reader Service Card

MICA PAPER INSULATION—Booklet, 8 pp. Covers properties, characteristics and typical applications. Mica Insulator Div, Minnesota Mining & Mfg Co, Schenectady 1.

Circle 341 on Reader Service Card

ORGANIC HEAT-TRANSFER-FLUID HANDLING—Bulletin 6, 9 pp. Discusses handling of organic heat-transfer fluids and use of sealless "canned" pumps. Fostoria Corp, PO Box 35-25, Huntingdon Valley, Penna.

Circle 342 on Reader Service Card

MECHANICAL BREADBOARD COMPONENTS—Booklet 14, 24 pp. Design recommendations for use of mechanical breadboard components in actual-scale working models. Pic Design Corp, 477 Atlantic Ave, East Rockaway, NY.

Circle 343 on Reader Service Card

FILTRATION EQUIPMENT—Catalog GEO-506A, 8 pp. Describes filters and filtration media. Information is classified according to use, operating pressures and sizes. Commercial Filters Corp, 2 Main St, Melrose, Mass.

Circle 344 on Reader Service Card

PINS, STUMPS AND RIVETS—Catalog, 24 pp. Discusses various tension and lightweight fasteners, driving cycles,

continued on page 90

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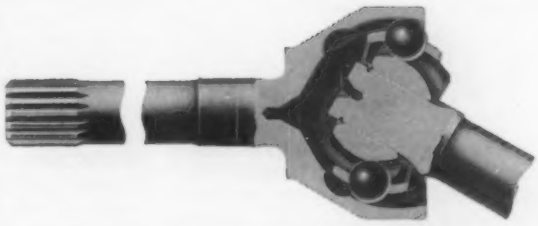

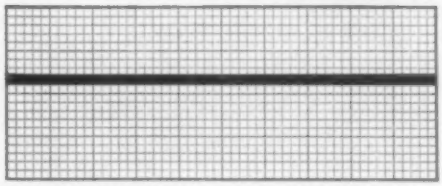

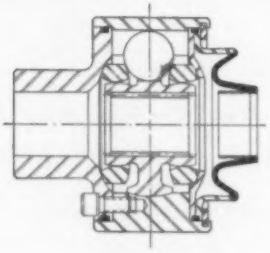

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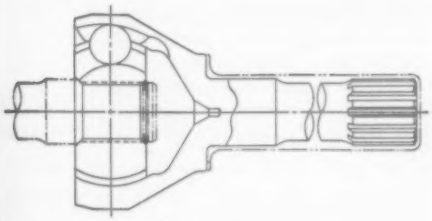

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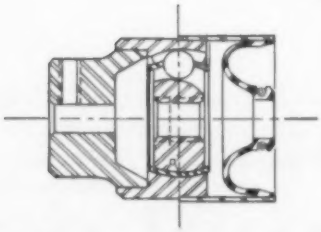

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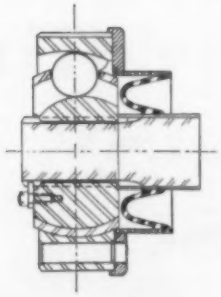

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Circle 345 on Reader Service Card

FASTENER APPLICATIONS – Brochure, 17 pp. 17 case histories of assembly-cost savings are illustrated and described. Tinnerman Products Inc, PO Box 6688, Cleveland 1.

Circle 346 on Reader Service Card

CHAIN AND SPROCKETS–Bulletin A691, 56 pp. Presents selection data, specifications, list prices and general information. Dodge Mfg Corp, Mishawaka, Ind.

Circle 347 on Reader Service Card

ELECTRIC TACHOMETERS–Catalog, 4 pp. Covers 9 tachometer indicators and 6 electric generators for tachometer service. Madison Electric Products Inc, Madison, Ohio.

Circle 348 on Reader Service Card

BUTT-JOINT FITTINGS–Catalog 3108, 44 pp. Styles, sizes and materials of stock items are listed with dimensions for each. Sections cover pressure, vacuum, temperature, vibration, corrosion resistance, port seals, flow and velocity characteristics, as well as laboratory reports and assembly instructions. Imperial Brass Mfg Co, 6300 W Howard St, Chicago 48.

Circle 349 on Reader Service Card

ELECTRICAL CONNECTORS–Bulletin B-77, 4 pp. Discusses basic design of connectors, performance, special designs and characteristics. Describes standard in-stock styles. Joy Mfg Co, 1201 Macklind, St Louis.

Circle 350 on Reader Service Card

AIR-PRESSURE AND GAS-DENSITY SWITCHES–Data sheets (4), 2 pp each. Specifications, characteristics, typical application and dimensional drawings for two absolute-air-pressure switches and two gas-density switches. Newark Controls Co, 15 Ward St, Bloomfield, NJ.

Circle 351 on Reader Service Card

CARBIDE PRODUCTS–Booklet, 8 pp. Summarizes properties and characteristics of 26 new products developed to resist abrasion, chemicals, corrosion, nuclear radiation and high temperatures. Carborundum Co, Dept BMD, Niagara Falls, NY.

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CABLES VS APPLICABLE CONNECTORS–Selection guide, 4 pp. Cross-reference listing of cables vs applicable connectors facilitates selection of connectors for specific cable. Also includes guide for adapters between series. Schweber Electronics, 60 Herricks Rd, Mineola, NY.

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NET WEIGHTS AND STRENGTHS OF WIRE ROPE–Bulletin 6025, 4 pp. In addition to net weights and strengths of wire rope, bulletin explains and describes constructions and types. Macwhyte Wire Rope Co, Dept PR, Kenosha, Wis.

Circle 354 on Reader Service Card

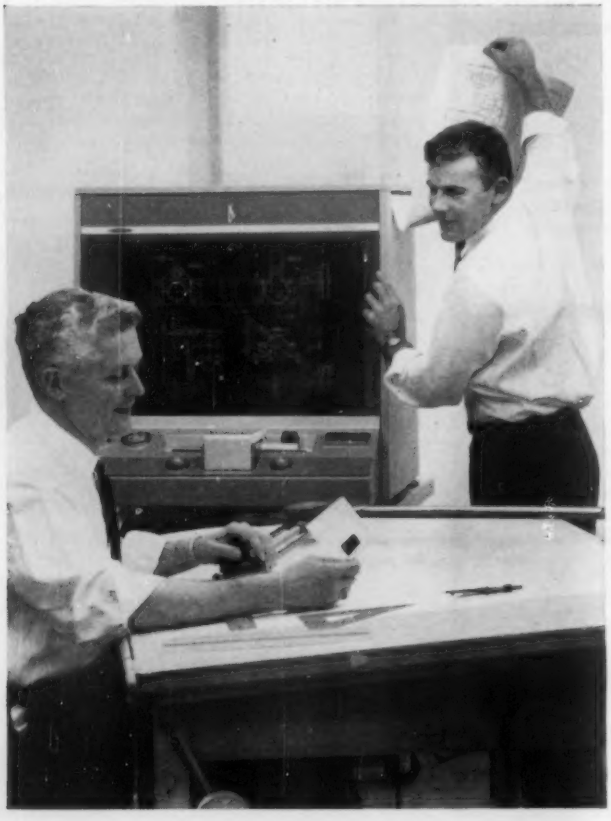
MAGNETOHYDRODYNAMICS–Booklet, 4 pp. Outlines work done at GE Space Sciences Laboratory in extracting electric power directly from ionized gas as it passes through a magnetic field. General Electric Co, Philadelphia 4.

Circle 355 on Reader Service Card

PHASE-SEQUENCE RELAYS–Bulletin 2001, 4 pp. Presents 18 standard phase-sequence relays that offer automatic monitoring of three-phase power. Master Specialties Co, 956 E 108th St, Los Angeles 59.

Circle 356 on Reader Service Card

FABRIC, FOIL, PLASTIC AND FILAMENT PACKINGS–Catalog and price list, 8 pp. Nine constructions are illus-



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PUSH-PULL TESTER—Data sheet, 2 pp. Illustrates and describes tester and test stand that can be used with any of five capacity push-pull gages, ranging from 0.01 to 25 lb. Testing Machines Inc, 72 Jericho Turnpike, Mineola, NY.

Circle 358 on Reader Service Card

PRINTED-CIRCUIT-BOARD HOLDER—Catalog sheet, 2 pp. Specifications, construction and features of No. 160 printed-circuit-board holder. Macdonald & Co, Dept L-1, 1324 Ethel St, Glendale 7, Calif.

Circle 359 on Reader Service Card

DESIGNING FOR CHROME DIFFUSION ALLOYING—Bulletin 40, 2 pp. Recommendations for parts to be surface alloyed by diffusion method. Drawings show proper radii and blending of corners. Schematics compare coated part with conventionally coated part. Chromalloy Corp, Dept PE, 452 Tarrytown Rd, White Plains, NY.

Circle 360 on Reader Service Card

PERSPECTIVES

If You Haven't Written, You Haven't Thought

Just what is a scholar? Must he spend all his time in a university library or laboratory? Or are his chief characteristics the same as those of open-minded searchers after truth in all professions?

Dr Edmund S. Morgan is a professor of history at Yale. A talk he made to this year's class of freshmen was published in the *Saturday Review*. Here is a much condensed version of his talk:

"The world does not much like curiosity. The world says that curiosity killed the cat. The world dismisses curiosity by calling it idle . . . even though curious persons are seldom idle. Parents do their best to extinguish curiosity in their children, because it makes life difficult to be faced every day with a string of unanswerable questions. Children whose curiosity survives parental discipline and who manage to grow up before they blow up become scholars.

"Some of the questions that scholars ask seem to the world to be scarcely worth asking, let alone answering. They ask about the behavior of protons, the dating of a Roman coin, the structure of a poem. If the world inquires of one of them why he wants to know the answer to a particular question, he may say, especially if he is a scientist, that the answer will in some obscure way make possible a new machine or weapon or gadget. He talks that way because he knows that the world understands and respects utility and that it does not understand much else. But in reality he wants to know the answer simply because he does not know it, the way a mountain climber wants to climb a mountain simply because it is there.

"A second quality that makes a scholar has no apparent relation to the

continued on page 93

■ Each month more and more companies are turning to microfilm for engineering drawing reference systems. The reasons are many—but, most important is that 3M's new THERMO-FAX "Filmac 200" Reader-Printer makes microfilm so practical—so easy to use. ■ The "Filmac 200" Reader-Printer combines the advantages of a reader and a printer in a single low-cost unit. You can refer to the enlarged drawing clearly projected on the big screen, and make a work-size print in seconds. You can take more than a look—you can take a copy. You make copies of what you need when you need them. So low in cost, it puts microfilm in reach of even the smallest engineering firm or department. ■ If you are now using microfilm you will find the "Filmac 200" Reader-Printer will fit into your present reproduction system perfectly. Engineers save valuable time—in seconds your reproduction department can make enlarged prints for them—or they can even make their own. If you are considering microfilm, investigate the "Filmac 200" Reader-Printer first. Its low initial cost and low operating cost—plus its fast and simple operation—make the microfilm reference system practical and so easy to use.

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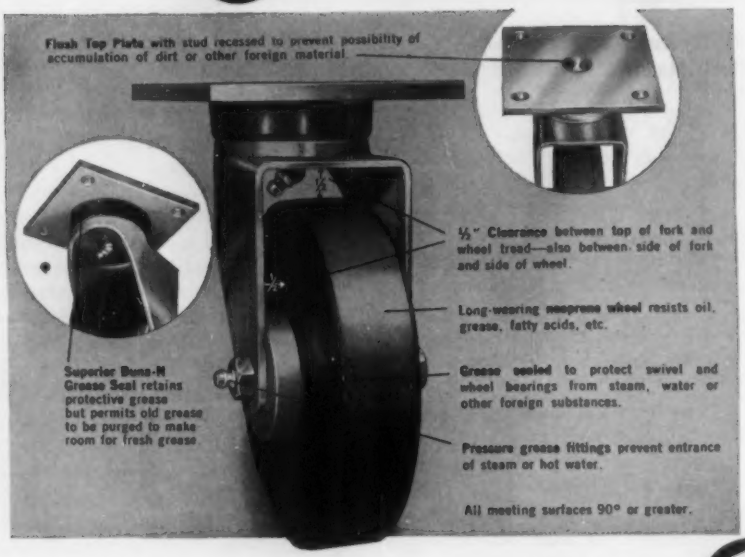
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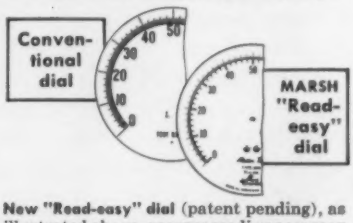

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first and yet is inseparably connected to it. It is a compulsion to communicate. A scholar is driven by a force as strong as his curiosity, that compels him to tell the world the things he has learned. He cannot rest with learning something; he has to tell about it.

"Communication is not merely the desire and the responsibility of the scholar; it is his discipline, the proving ground where he tests his findings against criticism. Without communication, his pursuit of truth withers into eccentricity. He necessarily spends much of his time alone, in the library or the laboratory, looking for the answers to his questions. But he needs to be rubbing constantly against other minds. He needs to be tested, probed and pushed around. He needs to be made to explain himself. Only when he has expressed himself, only when he has communicated his thoughts, can he be sure that he is thinking clearly.

"Many people suppose that they know something if they can stammer out an approximation of what they mean in speech. They are mistaken. It is extremely unlikely that you have thought clearly if you cannot express yourself clearly, especially in writing. Writing is more than an instrument of communication. It is an instrument of thought."

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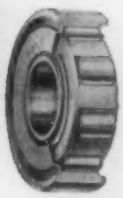

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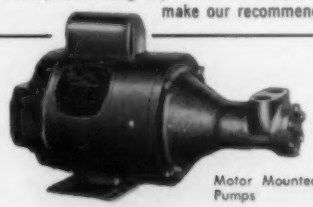
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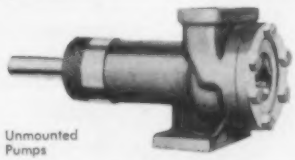
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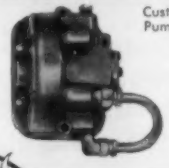
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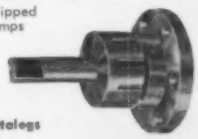

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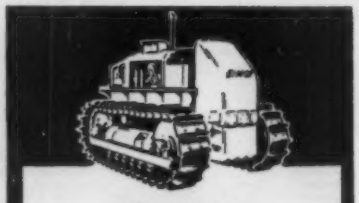

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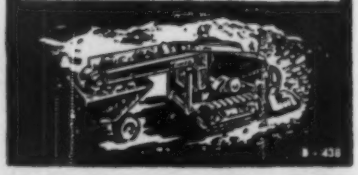

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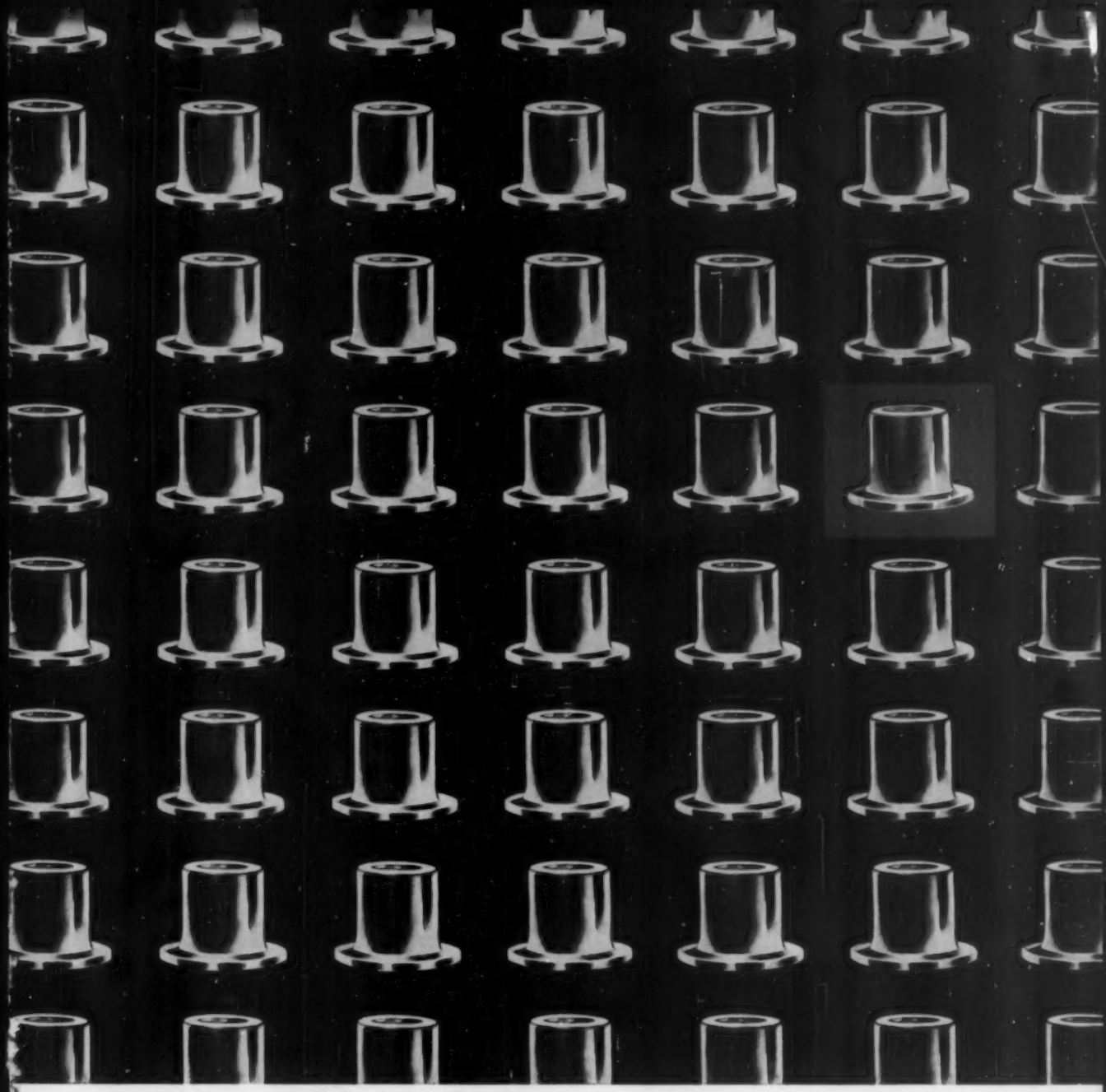

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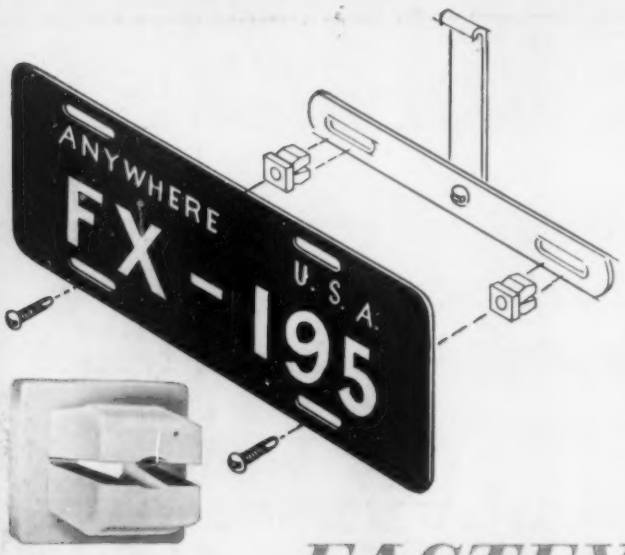

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